STATE OF ILLINOIS

ADLAI E. STEVENSON, *Governor*

TRANSACTIONS

OF THE

ILLINOIS STATE ACADEMY OF SCIENCE

VOLUME 42 1949

Forty-Second Annual Meeting

Galesburg, Illinois

May, 1949

PRINTED BY AUTHORITY OF THE STATE OF ILLINOIS

ILLINOIS STATE ACADEMY OF SCIENCE

AFFILIATED WITH THE

ILLINOIS STATE MUSEUM DIVISION, CENTENNIAL BUILDING

SPRINGFIELD, ILLINOIS

DECEMBER 31, 1949

Q 11
I 29
v. 42

STATE OF ILLINOIS
ADLAI E. STEVENSON, *Governor*

DEPARTMENT OF REGISTRATION AND EDUCATION
NOBLE J. PUFFER, *Director*

ILLINOIS STATE MUSEUM DIVISON
THORNE DEUEL, *Chief*

ILLINOIS ACADEMY OF SCIENCE

AFFILIATED WITH THE

ILLINOIS STATE MUSEUM

OFFICERS, COMMITTEES AND DELEGATES

1948-1949

I. OFFICERS

PRESIDENT: ROBERT F. PATON, University of Illinois, Urbana.
FIRST VICE-PRESIDENT: CLAUDE U. STONE, Peoria.
SECOND VICE-PRESIDENT: GEORGE H. REED, Knox College, Galesburg.
SECRETARY, HURST H. SHOEMAKER, University of Illinois, Urbana.
TREASURER: WILBUR W. GRIMM, Bradley University, Peoria.
LIBRARIAN: THORNE DEUEL, State Museum, Springfield.
EDITOR: DOROTHY E. ROSE, State Geological Survey, Urbana.
COLLEGIATE SECTION COORDINATOR: HARRY J. FULLER, University of Illinois, Urbana.
JUNIOR ACADEMY REPRESENTATIVE: GEORGE S. PORTER, J. Sterling Morton High School and Junior College, Cicero.

II. COUNCIL

The ACADEMY COUNCIL consists of the officers named above, the two most recent past presidents:
ERNEST L. STOVER, Eastern Illinois State College, Charleston.
LEO R. TEHON, Illinois State Natural History Survey, Urbana.
Past Secretary:
HURST SHOEMAKER, University of Illinois, Urbana.

III. SECTION CHAIRMEN

ARCHAEOLOGY AND ANTHROPOLOGY: C. C. BURFORD, Urbana.
BOTANY: R. M. MYERS, Western Illinois State College, Macomb.
CHEMISTRY: W. P. CORTELYOU, Roosevelt College, Chicago.
GEOGRAPHY: JOHN F. LOUNSBURY, Northwestern University, Evanston.
GEOLOGY: PERCIVAL ROBERTSON, Principia College, Elsah.
PHYSICS: A. FRANCES JOHNSON, Rockford College, Rockford.
PSYCHOLOGY AND EDUCATION: D. M. HALL, University of Illinois, Urbana.
SOCIAL SCIENCE: LYNFORD A. LARDNER, Northwestern University, Evanston.
ZOOLOGY: JAMES M. SANDERS, Chicago Teachers College, Chicago.
COLLEGIATE SECTION: HARRY J. FULLER, Coordinator, University of Illinois, Urbana.

IV. COMMITTEES

AFFILIATIONS: PERCIVAL ROBERTSON, Chairman, Principia College, Elsah.
ILDREM P. DANIEL, Lake View High School, Chicago.
HOWARD K. GLOYD, Chicago Academy of Sciences, Chicago.
LESLIE HEDRICK, Illinois Institute of Technology, Chicago.
ROBERT S. PLATT, University of Chicago, Chicago.
GLENN W. WARNER, Wilson Junior College, Chicago.

BUDGET: CLARENCE L. FURROW, Chairman, Knox College, Galesburg.
WILBUR W. GRIMM, Bradley University, Peoria.
LEO R. TEHON, State Natural History Survey, Urbana.
ERNEST L. STOVER, Eastern Illinois State College, Charleston.

CONSERVATION: HARLOW B. MILLS, Chairman, State Natural History Survey, Urbana.
LYELL J. THOMAS, University of Illinois, Urbana.
WARDER C. ALLEE, University of Chicago, Chicago.
VERNE O. GRAHAM, 4028 Grace St., Chicago.
WILLIAM H. HAAS, Northwestern University, Evanston.
L. A. HOLMES, Illinois State Normal University, Normal.

David Lansden, Cairo.
Morris M. Leighton, State Geological Survey, Urbana.
Raymond S. Smith, University of Illinois, Urbana.
Ernest L. Stover, Eastern Illinois State College, Charleston.
Floyd Cunningham, Carbondale.
Claude U. Stone, 210 W. Armstrong, Peoria.
Royal McClelland, 508 W. Charles St., Champaign.

CONSERVATION OF ARCHAEOLOGICAL AND HISTORICAL SITES: John B. Ruyle, Chairman, 1 Main St., Champaign.
Fay-Cooper Cole, University of Chicago, Chicago.
Morris M. Leighton, State Geological Survey, Urbana.
Claude U. Stone, 210 W. Armstrong, Peoria.
George R. Horner, Wheaton College, Wheaton.
C. C. Burford, 907 S. Orchard, Urbana.
Edgar Zook, Fairbury.
Wayne C. Townley, Unity Building, Bloomington.
John Hauberg, 23d St. Hill, Rock Island.
L. F. Gumbart, Macomb.
Irvin Peithman, Carbondale.
Frank W. Aldrich, 1506 East Washington St., Bloomington.

ECOLOGICAL BIBLIOGRAPHY: Arthur G. Vestal, Chairman, University of Illinois, Urbana.

HISTORY OF THE ILLINOIS STATE ACADEMY OF SCIENCE: William M. Bailey, Chairman, 506 S. Poplar, Carbondale.
George D. Fuller, University of Chicago, Chicago.
Otis B. Young, Southern Illinois University, Carbondale.

LEGISLATION AND FINANCE: Karl P. Schmidt, Chairman, Chicago Museum of Natural History, Chicago.
Morris M. Leighton, State Geological Survey, Urbana.
Frank W. Aldrich, 1506 E. Washington St., Bloomington.

LIVING MEMORIALS: Lyell J. Thomas, Chairman, University of Illinois, Urbana.
J. Nelson Spaeth, University of Illinois, Urbana.
E. E. Nuttila, State Forester, Springfield.
H. E. Hudson, State Water Survey, Urbana.
George E. Ekblaw, State Geological Survey, Urbana.
George W. Bennett, State Natural History Survey, Urbana.

MEMBERSHIP: John H. Garland, Chairman, University of Illinois, Urbana.
Gideon H. Boewe, State Natural History Survey, Urbana.
Durward L. Eaton, Northern Illinois State College, DeKalb.
George E. Ekblaw, State Geological Survey, Urbana.
W. H. Eller, 308 Sherman Ave., Macomb.
G. N. Jones, University of Illinois, Urbana.
Wellington D. Jones, University of Chicago, Chicago.
Orlando Park, Northwestern University, Evanston.
Hiram F. Thut, Eastern Illinois State College, Charleston.
Walter B. Welch, Southern Illinois University, Carbondale.
L. W. Miller, Illinois State Normal University, Normal.
Charles J. Widemann, Loyola University, Chicago.

PRE-MEDICAL TRAINING: Carlos I. Reed, Chairman, University of Illinois College of Medicine, Chicago.
Harold J. Eigenbrodt, North Central, Naperville.
G. H. Gardner, School of Medicine, Northwestern University, Evanston.
B. Vincent Hall, University of Illinois, Urbana.
Thesle T. Job, Loyola University Medical School, Chicago.
A. B. Luckhardt, University of Chicago, Chicago.
J. Roscoe Miller, School of Medicine, Northwestern University, Evanston.
F. J. Mullin, Dean of Medical Students, University of Chicago, Chicago.

PUBLICATIONS: The President, Robert F. Paton, University of Illinois, Urbana.
The Secretary, Hurst H. Shoemaker, University of Illinois, Urbana.
Howard K. Gloyd, Chicago Academy of Sciences, Chicago.
H. Bowen Willman, State Geological Survey, Urbana.
Leo R. Tehon, State Natural History Survey, Urbana.
Willard R. Gersbacher, Southern Illinois University, Carbondale.

PUBLIC RELATIONS: Claude U. Stone, Chairman, 210 W. Armstrong St., Peoria.
Harlow B. Mills, State Natural History Survey, Urbana.

RESEARCH DEVELOPMENT: Otis B. Young, Chairman, Southern Illinois University, Carbondale.
John C. McGregor, Illinois State Museum, Springfield.
Harold R. Wanless, University of Illinois, Urbana.
Claude U. Stone, 210 W. Armstrong, Peoria.
Percival Robertson, Principia College, Elsah.
Bruce Merwin, Southern Illinois University, Carbondale.
Carlos Reed, University of Illinois, College of Medicine, Chicago.
Harlow B. Mills, State Natural History Survey, Urbana.

RESEARCH GRANTS: Ralph O. Freeland, Chairman, Northwestern University, Evanston.
B. S. Hopkins, University of Illinois, Urbana.
Sister Mary O'Hanlon, Rosary College, River Forest.
H. R. Wanless, University of Illinois, Urbana.
Sister Joan Preising, College of St. Francis, Joliet.
Percival Robertson, Principia College, Elsah.
Charles J. Widemann, Loyola University, Chicago.
William Marberry, Southern Illinois Normal University, Carbondale.

SCIENCE TALENT: Lyell J. Thomas, Chairman, University of Illinois, Urbana.
J. T. Hastings, University of Illinois, Urbana.
E. F. Potthoff, University of Illinois, Urbana.
R. F. Paton, University of Illinois, Urbana.
E. L. Stover, Eastern Illinois State College, Charleston.
F. H. Reed, State Geological Survey, Urbana.
Hobart Smith, University of Illinois, Urbana.

SUSTAINING MEMBERSHIPS: Leo R. Tehon, Chairman, Natural History Survey, Urbana.
Robert L. Smith, Herrin High School, Herrin.
Audrey H. Lindsey, University High School, Urbana.

852184

STATE MUSEUM BUILDING: PERCIVAL ROBERTSON, Chairman, Principia College, Elsah.
CLARENCE L. FURROW, Knox College, Galesburg.
FRANK W. ALDRICH, 1506 E. Washington, Bloomington.
ERNEST L. STOVER, Eastern Illinois State College, Charleston.
FREDERICK C. HOLTZ, Sangamon Electric Company, Springfield.

DELEGATES

DELEGATE TO THE CONSERVATION COUNCIL: VERNE O. GRAHAM, 4028 Grace St., Chicago.

DELEGATE TO THE A.A.A.S.: ERNEST L. STOVER, Eastern Illinois State College, Charleston.

JUNIOR ACADEMY OF SCIENCE

GENERAL CHAIRMAN: GEORGE S. PORTER, J. Sterling Morton High School, Cicero.

ASSISTANT CHAIRMAN: ROBERT L. SMITH, Township High School, Herrin.

CHAIRMAN OF EXHIBITS: JOAN HUNTER, High School, Edwardsville.

ASSISTANT CHAIRMAN OF EXHIBITS: ELROY SMITH, High School, Galesburg.

CHAIRMAN OF JUDGING: ELINOR STOLDT, High School, Jacksonville.

ASSISTANT CHAIRMAN OF JUDGING: H. W. CRALL, Western Illinois State College, Macomb.

AREA REPRESENTATIVES:
Northern: JAMES HAYASHI, Northern Illinois State College, DeKalb.
Western: H. W. CRALL, Western Illinois State College, Macomb.
Eastern: MRS. MARY CREAGER, University High School, Charleston.
Southern: C. A. GROSS, University High School, Carbondale.
Central: J. C. CHIDDIX, Normal Community High School, Normal.

SENIOR ACADEMY ADVISOR: LYELL J. THOMAS, University of Illinois, Urbana.

Student Officers
President: CLYDE HIPPARD, J. Sterling Morton High School, Cicero.
Vice-President: BOB HARRIS, Township High School, Herrin.
Secretary: JO ANN MEINIEKE, High School, Taylorville.
A.A.A.S. Honorary Members: TOM SNOURE, Hitchcock Junior High School, Chicago; GLORIA KORVALOSKI, Immaculata High School, Chicago.

CONTENTS

PAGE

ADDRESSES

PATON, R. F., Available Energy 9
SANFORD, CHARLES W., The "Who" in the High School Science Program 12
SPALDING, WILLARD B., Training of Teachers for Tomorrow's World 21

PROGRAM

Papers Presented at the 42nd Annual Meeting 30

ARCHAEOLOGY AND ANTHROPOLOGY

GILLETTE, CHARLES E., Late Woodland occupations of the Fisher Site, Will County, Illinois 35
SCHOENBECK, E., More data on Hopewell sites in Peoria region 41

BOTANY

BAILEY, WILLIAM M., Initial report of the vascular plants of Southern Illinois 47
FELL, EGBERT W., and GEORGE B. FELL, Ferns of Rock River Valley in Illinois .. 56
KAEISER, MARGARET, Embryo development of the pond cypress (*Taxodium ascendens* (Brongn.) 63
FULLER, GEORGE D., EGBERT W. FELL, and GEORGE B. FELL, Check list of the vascular plants of Winnebago County, Illinois 68

CHEMISTRY

SISTER MARY MARGUERITE CHRISTINE, B.V.M., Place of science in general education 80

GEOGRAPHY

GARLAND, JOHN H., Occupance of the Mississippi border of Southern Illinois 85
SMITH, L. MARJORIE, The pulp and paper industry of the Lake states 91

GEOLOGY

GROGAN, ROBERT M., Present state of knowledge regarding the pre-Cambrian crystallines of Illinois 97
KNODLE, ROBERT D., Factors affecting measurement of permeability of unconsolidated glacial material 103
LOWENSTAM, HEINZ A., Facies analyses of the Niagaran rocks 113
SHRODE, RAYMOND S., Physical characteristics of the oölite grains of the Ste. Genevieve formation 116

PHYSICS

CONKLIN, RICHARD L., Investigation of a gamma-proton process in beryllium ... 120
ROBERTS, HOWARD C., and RICHARD E. WENDT, Electronic aids to control and measurement 123
SILKETT, A. F., and MAE A. DRISCOLL, Simple circuit for measuring variations in electrical resistance of a human being under emotional stress 128

SOCIOLOGY

HOUSER, FRANK E., The structure and institutionalization of a protest group ... 130
TUDOR, WILLIAM J., Southern Illinois—a cultural area 140

ZOOLOGY

PAGE

BLACK, JOHN D., Changing fish populations as an index to pollution and soil erosion 145
BRAUN GARWOOD A., and GEORGE I. DYNSTRA, A survey of the Unionidae of the upper reaches of the Mackinaw River 149
GOLDBERG, ROBERT J., Notes on the biology of a common gastrotrich of the Chicago area 152
MITTLER, SIDNEY, Genetic variation in populations of *Drosophila Melanogaster* in the Chicago area 156
NELSON, RUSSEL E., Incidence of Trypanosoma infection in small mammals of Champaign County, Illinois 159
WALTON, A. C., Parasites of Ranidae (Amphibia). XIV 161

COLLEGIATE SECTION

REID, W. MALCOM, SHIRLEY JEAN NICE, and RHODA COOPER MCINTYRE, Certain factors which influence activation of the hexacanth embryo of the fowl tapeworm *Raillietina cesticillus* 165

MEMORIALS

CHARLES TOBIAS KNIPP 169
MARGARET ENGSTROM 171

ACADEMY BUSINESS

Secretary's Report for 1948-1949 173

ROBERT F. PATON, *President*, 1948-1949

PRESIDENTIAL ADDRESS

AVAILABLE ENERGY

R. F. PATON
President, Illinois State Academy of Science

There is much current writing and discussion about energy and, in particular, the atomic and nuclear variety. Concerning the concept of energy, there is some careless thinking and frequent misconception. For we live in a universe filled with many different forms of energy which are never destroyed but which may be transformed. When energy is needed for any purpose, it must be supplied in a form suitable for the job intended. It is customary to think of such energy as available energy and to ignore other forms as if they did not exist, simply because they are not available.

To illustrate this, consider the immense amount of energy in an ocean. Such a supply is usually thought of as heat energy. Some of this energy goes to melt icebergs; is replenished by absorption of light from the sun; but cannot be used to propel a boat. To be available to operate a boat, the energy must be at a higher temperature than the ocean. Hence, the energy from burning fuel is available, in part at least, to drive the engine in the boat.

Fuel energy available for heating and for operating engines has been stored in the earth by plants and the like, having originally come from the sun. The sun sends out energy at such a tremendous rate that if all that strikes the earth could be retained and stored, there would be enough in a few weeks to equal all that stored as gas, oil, coal, and oil-shale over the millions of years that the sun has been shining on the earth. This seems surprising, but plants are very inefficient at trapping and storing solar energy, yet no other general means has ever been devised. Solar energy is given off by our sun, whose effective surface temperature is about 6000°C. This is almost too hot to be used in an engine, but is so very diffuse that only about 2 calories per square centimeter per minute is received from the sun at the earth.

To be available, energy must have appropriate temperature and concentration. In an engine, temperatures as high as 2000°C can be readily managed. Higher temperatures soon become troublesome, for there are no satisfactory materials for building engines which will be durable at such temperatures. Energy coming from known chemical reactions can maintain temperatures of a few thousand degrees. In internal combustion engines, turbines, and rockets, such energy is used for propulsion or transformation into electrical form.

Suppose Q_1 to be the heat of some chemical reaction in some mixture

such as a hydrocarbon and oxygen. This energy may be thought of as a quantity supplied to an engine. Receiving this energy allows the engine to do an amount of work, W. A large part of Q_1 is, however, always discarded, as hot gases for instance in an internal combustion engine, and also in cooling devices designed to assimilate the discarded part of Q_1 under circumstances as favorable as practicable. Calling the discarded energy Q_2, the law of conservation of energy—also known as the first law of thermodynamics—says that

$$Q_1 = W + Q_2 \qquad (1)$$

When fuels are burned in a furnace and used for heating, Q_1 is evolved at say 1500°C, W is zero, and Q_2 is equal to Q_1, appearing as heat at the temperature level desired, say 20°C. Q_1 is available for use as heating energy only if its temperature is above 20°C. All the heat in the ocean cannot supply even heat to a boat unless the ocean temperature is higher than that desired in the boat. It is a characteristic of all heat energy that it cannot, of itself, flow uphill in temperature. This, in a superficial way, is a statement of the second law of thermodynamics.

The process suggested in equation (1) is not an entirely reversible process. However, heat to an amount Q_2 can be taken out of the inside of a refrigerator, for example by supplying an appropriate amount of work W with a motor or some equivalent device. The result of this process is

$$Q_2 + W = Q_1 \qquad (2)$$

The heat Q_1 is rejected by the hot coil of a refrigerator to its surroundings while Q_2 is removed from the inside. Q_1 is greater than Q_2 by an amount W. Equation (2) gives, in principle, the heat pump. In winter, for instance, Q_2 may be taken from the water in a deep well, an amount W added to it with a suitable motor, and the entire amount Q_1 used to heat the house. The only part of this energy which is supplied by a commercial fuel is W. Since Q_2 types of heat energy are available in essentially limitless supply, great savings on the more costly type of energy, represented by W, can be accomplished by using sources whose supply of Q_2 is almost available.

In the ideal engine, it is possible to get work W from heat Q_1 to an amount

$$Q_1 - Q_2 = W \text{ where } \frac{Q_1}{Q_2} = \frac{T_1}{T_2} \qquad (3)$$

T_1 and T_2 are the absolute temperatures of the hot, Q_1, source and the cold, Q_2, source respectively. Any actual engine will not do as well as equation (3). The efficiency of an engine is given by

$$\frac{W}{Q_1} = \frac{Q_1 - Q_2}{Q_1} < \frac{T_1 - T_2}{T_1} \qquad (4)$$

In a case where fuel maintains T_1 at say 10,000°K (K = °C on absolute scale) and a cooler takes rejected heat at 500°C, the efficiency will always be less than $\frac{10{,}000 - 500}{10{,}000} =$ 95 percent but may approach this 95 percent in an ideal case. (See equation 4).

This brings us to the atomic problem. In the bomb, temperatures of 100,000,000°K are probable. But the efficiency of an engine run by such energy will be conceivably equal to

$$\frac{100{,}000{,}000 - 500}{100{,}000{,}000} = 99.9995 \text{ percent}$$

at best. This is very little better than the 95 percent efficiency. Further more, there is no material for construction which will hold together at even the 10,000°K. To use atomic nuclear energy, massive installations are neeessary to lower the temperature of this energy to below the 10,000°K level before it can be used for practical purposes. Only a very few processes above the 10,000°K level are of any interest to the everyday world. One of these, the destruction by atomic bomb, we almost wish had never been discovered. Mankind lives at around 300°C. Processes involving energy at temperatures far from this value are dangerous and apt to be highly destructive. They are the really unavailable types of energy.

There is a vast supply of energy just below the 300°K level in this earth everywhere about us. Using a heat pump, it is quite possible to make this energy available, and increasingly engineering is making it practical to utilize this energy for heating purposes. The plant which traps solar energy in fuel form maintains itself in this earth at suitable temperature and in a very real sense is able to trap the solar energy in a usable form. Solar energy traps designed to bypass the plant will surely use the heat pump also, for the solar energy comes from such a high temperature source that, to a large percentage, it may be thought of as a *W* form and is correspondingly useful if sufficiently concentrated.

The only practical advantage of nuclear energy is that it can be tremendously concentrated, though so far the process has been tremendously expensive. New processes unknown and unimagined as yet must be discovered if the possibilities of nuclear energy which can be associated with temperatures above 10,000°K are to prove useful. These energies will then be "available" in the usual sense.

MORNING ADDRESS

THE "WHO" IN THE HIGH SCHOOL SCIENCE PROGRAM*

CHARLES W. SANFORD

Director, Illinois Secondary School Curriculum Program and Coordinator of Teacher Education, University of Illinois

All of you are aware of the structure of the Illinois Secondary School Curriculum Program. It is sponsored by the State Superintendent of Public Instruction, Vernon L. Nickell, in cooperation with colleges and universities and 38 lay and professional organizations. Among the cooperating organizations are the Illinois Association of Chemistry Teachers, represented by T. A. Nelson of LaGrange, the Illinois Association of Teachers of Biology, represented by J. S. Tucker of Centralia, and the newly organized or re-organized Illinois Council of Mathematics Teachers represented by Miss Gertrude Hendrix of Eastern Illinois State College.

Numerous unanswered questions regarding "The Who in the High School Science Program" and other similar items were largely responsible for the decision by the steering committee of the Illinois Secondary School Curriculum Program that assistance and encouragement should be given to every participating school and community to get the facts about itself that are basic to curriculum revision. The committee correctly insisted that we have, for too long, made curriculum changes on the basis of hunches or as a result of super-salesmanship by someone.

The implementation of this decision to ferret out the facts called for the structuring of a series of local factual studies designed to locate answers regarding "Who?", and in addition, "What?", "When?", and "How?". Four studies concerned largely with the "Who?" and "What?" were variously conducted in 135 Illinois high schools during the past year.

Before turning to an analysis of these studies, it may be apropos to state that we are not unmindful of the many accomplishments of our schools. The high schools have increased their holding power; virtual equality obtains among the educational opportunities afforded to boys and girls and men and women; teachers are better trained; physical plants have been improved; better textbooks are available; improved instructional equipment is used, including many audio-visual aids; the instructional program has been enriched by the addition of work in such areas as health, physical education, art, music, agriculture, home economics, work experience, social and personal relationships, and conservation; advances have been made in relating the subjects taught to

* Portions of this article are quoted from the following reference: Sanford, Charles W. "Challenging Developments in the Illinois Secondary School Curriculum Program", *The Bulletin of the National Association of Secondary-School Principals"*, Volume 33, Number 162, April, 1949, p. 57-65.

life; and education is now generally looked upon as a continuous process lasting throughout life, with few persons regarding education as completed when a certain age has been reached.

These accomplishments, and others which might be cited, show that change is possible. All of us are well aware of the forces that have operated in producing these changes; moreover, all of us realize that many of these same forces, and others, are presently pointing to the necessity for further changes. These accomplishments demand our admiration, but we must, if we are realistic, look long and hard at certain problems that now obtain and at certain facts which we now have.

One such problem is this: "Is the holding power of our schools satisfactory in terms of accepted democratic goals?" Let us look first at some national figures.[1] For every 1000 pupils in the fifth grade in 1932-33, 786, or about 78 per cent, entered the ninth grade in 1936-37. Thus, our 4-year high school consisting of grades 9-12 had no chance at all to work with 22 per cent of the youth of high school age. Of the original 1000, 664, some 66 per cent, found their way into the tenth grade; 570, or 57 per cent, entered the eleventh grade; 510, 51 per cent, started the twelfth grade; and 455, approximately 45 per cent, were graduated. Certainly we can clearly see in these data substantiation for Provost Griffith's recent statement that American education ". . . has given too little to too few." Of the original 1000 fifth grade pupils 160, or 16 per cent, entered some college and 47, about 4 per cent, were graduated in 1944.

In the belief that national figures of this type ordinarily do not, and should not, convince persons connected with a local school that its holding power is deficient, the steering committee for the ISSCP decided to conduct a holding power study in a number of Illinois schools. The committee correctly reasoned that evidence must be obtained regarding local withdrawals if reasons for these withdrawals are to be examined and corrected. As a consequence, during the past year, a holding power study was conducted in 76 representative Illinois high schools. Three assumptions underlay this study:

1. That the secondary school is expected to serve all the children of all the people, and that the school can serve most adequately those children who are in school.

2. That the types of children who have dropped out of school in the past are the types most likely to drop out in the future, if present practices remain unchanged.

3. That the school, by changing its practices, can influence children to remain in school.

In each school, information was obtained to help us determine what proportion of all enrollees dropped out of school, at what times they dropped out, and what kinds of students they were in terms of such factors as economic status, I. Q., school success, course of study pursued, extent and nature of participation in extra-curricular activities, distance of the home from the school, behavior problems, and out-of-school

[1] Statistical Summary of Education, Ch. I, U. S. Office of Education, Biennial Survey of Education, 1942-44, p. 31.

employment. Perhaps it is significant to note that all of these 76 schools had stated that they wanted to participate in this study. This same policy operates in all phases of the ISSCP. The program is in every respect voluntary; a school may participate or not, as it wishes.

Our composite findings from this study revealed that in Illinois boys dropped out in larger proportions than girls; that almost all of the drop-outs were receiving, when they withdrew, very low marks; that children from lower-income families dropped out in much larger numbers than those in the middle- and upper-income groups; that there was no appreciable difference in the holding power of small and large high schools, and so on. They also revealed that while Illinois schools have a better holding power than was cited for the country as a whole, there is still much to be done to increase holding power in Illinois. The range in drop-outs was from less than one to as many as eight for every ten who were graduated. On the average, for every ten who received diplomas, approximately three had dropped out. Since the study included only those pupils who started in the ninth grade, we can safely say that, for every ten who were graduated, considerably more than three youths of secondary school age were not in school. These state-wide summaries and others, together with data for each local school, have been returned to participating schools for use in the formulation of hypotheses regarding local curriculum changes which may lead to an increase in holding power. Certainly the data for each school furnish convincing evidence regarding vulnerable points for intensive study looking toward promising change.

With these drop-out figures for Illinois and the United States before us, let us look at the picture in science. Three sources provide a fairly good picture, though we must say that the picture needs to be defined even more clearly. First, we cannot offer high school science to youth who are not enrolled in any type of private or public secondary school.

The national picture was presented earlier. It indicated that, in round numbers, between 30 and 40 percent of the youth of high school age are not in school, and as a consequence, are receiving no instruction in science. "In 1940-41, the best year of our history as far as high-school enrollments are concerned, only 73 per cent of our youth of high-school age were enrolled in high schools."[2]

In addition to these data and those presented for 76 high schools in Illinois, we might look at the summaries in the annual statistical reports of the Office of the Superintendent of Public Instruction. They indicate that during the year of July 1, 1939 to June 30, 1940,[3] there were 103,239 pupils in the fifth grades of our public schools; in the period of July 1, 1946 to June 30, 1947,[4] there were 62,841 in the twelfth grades. Thus, 40,398 were lost between the fifth and the twelfth grades.

[2] *Life Adjustment Education for Every Youth.* Federal Security Agency, U.S. Office of Education, Washington, D.C., 1948, p. 11.

[3] *Annual Statistical Report of the Superintendent of Public Instruction,* State of Illinois for the Year Ended June 30, 1940. Office of the Superintendent of Public Instruction, Springfield, Illinois, No. 328, p. 252.

[4] *Annual Statistical Report of the Superintendent of Public Instruction,* State of Illinois for the Year Ended June 30, 1947. Office of the Superintendent of Public Instruction, Springfield, Illinois, Circular Series A, No. 47, p. 352.

Second, a random sample of 114 Illinois public high schools ranging in size from 32 to 2,018, with a proportionately larger number of schools included below 250, in accordance with the proportion which obtains between small and large high schools in Illinois, indicated that in 1947-48, 19 percent of all high school students were taking general science, 19 percent biology, 6 percent physics, and 7 percent chemistry. The population of these 114 schools was 27,878, approximately 9 percent of those attending all Illinois public high schools.

Third, college-bound students probably take more work in science than those who do not enter some university. In an effort to discover how many students entering the University of Illinois had completed courses in science in high school, a study was made of the high school records of 100 students who entered the University in September 1948. Of this group, 63 had completed one unit in biology; 70, one unit in physics; 62, one unit in chemistry; and 80, one unit in some other science, usually general science. Thirteen students had completed a total of one unit in science; 28, two units; 31, three; and 28, four. The average number of units of science taken by these 100 students was 2.74.

These data indicate clearly (1) that all of us are confronted with a major task in trying to keep in school a larger proportion of the youth of secondary school age and (2) that all of us need to examine very critically our present science offerings, especially the work in the 9th and 10th grades. Is the traditional course in general science adequate for the large number who will receive no more? If not, what should be offered? How may we be reasonably sure that what we propose is adequate? Certainly all of us will take every step within our power to decrease the number of drop-outs; but while we are doing so, we have to be realistic and work with what we have.

Let us look at both of these questions. It was stated earlier that many Illinois high schools are attempting to increase their holding power through self-study projects followed by the testing of locally formulated hypotheses. One of these projects was concerned with the question, "Are the costs connected with certain phases of the school's program depriving some youth of the very experiences they need?" Also, we might ask whether or not the facts indicate that costs are the cause of some of our drop-outs. Many Illinois high schools attempted to obtain, during the past year, the facts concerning the identity and the amount of the full range of these costs. For want of a better name we called them "hidden tuition costs." Our composite findings in 79 representative schools, and here I am including grades 7-12, indicated that science textbooks were most commonly rented to pupils, that pupils purchased their books in from about a third to somewhat over half of the schools, and that it was only in the two lower grades, grades 7 and 8, that over 10 percent of the institutions provided free textbooks. Two out of every five high schools required eleventh and twelfth grade pupils to pay a special fee, assessment, or deposit in science courses, but this practice was much less fre-

quent at the lower grade levels. From about two-thirds to over nine-tenths of the schools, depending upon the grade-level of the course, required pupils to purchase special materials or items of equipment in science. The median costs to pupils who attended schools in which textbooks were purchased by the pupils was $2.50 for seventh grade science, $2.40 for eighth grade science, $3.10 for ninth grade science, $3.90 for tenth grade science, $3.60 for eleventh grade science, and $3.75 for twelfth grade science. The lowest costs reported were nothing in grades 7, 8, 9, 10, and 11, and $0.50 in grade twelve. The highest costs to pupils who attended a school in which textbooks were purchased by the pupils was $2.76 for seventh grade science, $2.90 for eighth grade science, $3.85 for ninth grade science, $7.50 for tenth grade science, $6.60 for eleventh grade science, and $10.25 for twelfth grade science. The median costs of belonging to the biology and science clubs were $2.50 and $1.25, respectively; the highs were $7.50 and $39.90 respectively. Similar data were obtained for all subjects and extra-class activities offered in these schools.

Obviously, these state-wide summaries have relatively little significance except as they may serve as a basis for comparisons and as they may serve to stimulate local investigations leading to adjustments and corrections. Each school, then, must analyze the implications of cost facts of the type mentioned. Do high costs lower the holding power of the school? Do the costs of certain activities and of certain subjects mean that some pupils who need those activities do not participate in them? If so, how can we answer the charge that the school is not serving equally well all of the children of all of the people? One of my colleagues at the University of Illinois, Professor Harold C. Hand, has very neatly pointed, in the following words, to answers for these questions:

1. The school is by definition an *educational* institution.
2. As such, it cannot legitimately permit, much less sponsor, any activity (whether class or extra-class, formal or informal) which is not educative in nature.
3. If the activities permitted or sponsored are educative in nature, no public school in a democracy can justify making the accident of birth in an economic (or any other) sense determine who shall and who shall not benefit from said educative activities.[5]

Next, let us examine briefly the questions posed earlier, namely, "Is the traditional course in general science adequate for the majority who will receive no other work in science?" "If not, what should be offered?" "How may we be reasonably sure that the 'what' we propose is adequate?" Means are suggested for obtaining answers to these questions in the *Guide to the Study of the Curriculum in the Secondary Schools of Illinois*. I quote from the *Guide*.

The first and most fundamental policy being followed in the ISSCP is that curriculum improvement is a *grass roots* job, that any changes which may take place should be the result of the work of teachers, administrators, and lay persons in local schools. Although consultants from outside local schools will be available to provide assistance as needed, the real source of power in the operation will come from local schools rather than from outside.

[5] Hand, Harold C., *Principal Findings of the 1947-1948 Basic Studies of the Illinois Secondary School Curriculum Program*. Circular Series A, No. 51, Illinois Secondary School Curriculum Program Bulletin No. 2, Office of the State Superintendent of Public Instruction, Springfield, Illinois. May, 1949, p. 64.

The purpose of the school is to provide learning experiences so that the needs of youth and the requirements of society may be met effectively. The means of accomplishing that end, that is, the selection of what learning experiences may best meet youth and societal needs, constitutes a basic task of curriculum makers.

Curriculum construction might, therefore, be viewed in part as a sifting process wherein a selection from all possible learning experiences is made. What youth need and what society seem to require may constitute the sieve. All of the accumulated social and cultural heritage is available to those who teach. The teacher must select those experiences which will be most profitable to youth and adults.

Since all youth have certain needs in common and the social setting presents certain requirements common to all citizens in a democracy, a portion of the school day may be devoted to these "common learnings" of all youth. This would not change the policy of providing a wide offering of other subjects on an elective basis.[6]

The *Guide* suggests certain basic needs of high school youth, and it presents several statements of the purposes of the high school. In the Follow-Up Study which is presently underway in 100 high schools, we have defined 55 problems of high school youth which stem from these needs. Needs, purposes, and problems must be considered, but they only introduce us to the "specifics" to be used in the classroom. Certainly the introduction is a basic one, but it points only to the kinds of pupil activities which go on in the classroom. At this point we have found that the consultants from the colleges and universities who are cooperating with the Illinois Secondary School Curriculum Program render their greatest service.

[6] Houston, Victor M., Sanford, Charles W., and Trump, J. Lloyd, *Guide to the Study of the Curriculum in the Secondary Schools of Illinois.* Circular Series A, No. 51, Illinois Secondary School Curriculum Program Bulletin No. 1, Office of the State Superintendent of Public Instruction, Springfield, Illinois. August, 1948, pp. 9 and 10.

At the present time, as most of you know, the ISSCP is cooperating with 33 selected school systems in attempting to develop 58 projects. These projects are concerned with the improvement of existing courses in English, mathematics, science, social studies, etc.; with enrichment in broad fields; with development of common learnings courses; and with projects which cut across subject lines.

The ISSCP does not suggest any one type of curriculum improvement project as best for a given school. Decisions of this type should be made by teachers, administrators, and others working together to improve the curriculum in local schools. Each school is encouraged to start where it is, with what it has, and on that in which it is vitally interested.

A team of consultants from the colleges, universities, State Department, and other high schools cooperate with persons affiliated with local schools in attempting to develop superior programs. If and when superior programs have been developed, the local teachers and administrators will help other schools on similar projects. Moreover, as the local projects are being developed, teachers and administrators from other schools are encouraged to study what is going on.

The findings from the basic studies conducted in these schools are of inestimable value in building a broadly based local concensus regarding what needs to be done and in furnishing numerous "specifics" which merit attention.

It would be premature, after only one and a half years of work, to try to relate many of the emphases and

re-directions that are taking form in these projects. However, several have become crystal clear. They are:

1. The energies of our faculties and of others who are interested in secondary education must be directed toward meeting more adequately the needs of all youth, not the needs of one or two or three groups of youth.

2. In those schools in which developmental projects are underway, emphasis is being placed on real-life problems.

3. Whenever such problems are stressed, we find in the schools more and more emphasis on good work habits, how to work with others, understanding ourselves, developing a zeal for the democratic way of life, conservation, health, problems of community, state, national, and international concern, and the choice of appropriate school subjects.

4. Whenever such problems are stressed we also find more and more attention given to sharpening the guidance program to the end of identifying as early as possible the interests and abilities of students so that there may be provided learning experiences which will be of greatest value.

I wish that time permitted a development of this problem as it relates to locating youth with superior abilities, keeping them in school, and providing curricular experiences of maximum value.

5. It is becoming increasingly obvious that curriculum change is a "grass-roots" proposition. Persons from outside a given school system may be ready and anxious to cooperate with local schools, but little is accomplished unless the dynamic for local projects obtains within the local group.

6. Curriculum work which is effective calls for a high order of cooperation. At the local school level, this cooperation means participation by many members of the faculty; ideally, by all members of the faculty. It also means participation by school board members, by parents, by laymen who are not parents, and by pupils.

7. I hope I am correct in the observation that the schools, at least most of them, which have developmental projects underway have agreed that meeting the needs of all youth of secondary school age becomes a reality only when those concerned are obsessed with the notion that *all* youth of high school age are the business and concern of the high school. We must accept this notion or face the alternative. The alternative is that we shall let some other agency assume a part of the responsibility—another NYA perhaps.

Another study in the series sponsored by the ISSCP was concerned with the question, "Are pupils in our high schools participating in extracurricular activities according to their needs, interests, and abilities?" Do certain factors operate which make participation selective in one or more respects?

In the study which we conducted, we related extent of participation with sex, age, grade in school, location of school, mode of transport, acceleration-retardation, and socio-economic status. The data were then analyzed on the basis of each of the factors noted. The only factor identified which was associated with the number of participations was socio-

economic status, the accident of birth in an economic sense.

In all types of participation, there was less participation by children from low income families, somewhat more by children from middle income families, and by far the most by children from upper income families.

A fourth study was concerned with the problem, "Are the available guidance services both adequate and effective?" In all, or nearly all, schools some pattern of organized personnel services has been developed for students. These services may be concerned with the educational, occupational, social, and personal adjustments of young people.

Our investigation was carried on in 96 schools. We used three instruments, namely, the *North Central Association Check List of Elements in a Minimum and an Extended Program of Guidance and Counseling*, the *Illinois Revision of the Kefauver-Hand Guidance Test*, and the Ross L. Mooney *Problem Check List*. Our findings indicated that the major concerns of girls were in the area of Personal-Psychological Relations: "Losing my temper," "Nervousness," "Worrying," "Can't make up my mind about things," "Can't see the value of daily things I do," etc. The boys were most concerned with problems of Adjustment to School Work: "Taking wrong subjects," "Not getting studies done on time," "Worrying about grades," "Slow in reading," "Trouble in using the library," "Can't see that school is doing me any good," etc. Both boys and girls were bothered about problems concerned with Curriculum and Teaching Procedures: "Dull classes," "Made to take subjects I don't like," "Poor place to study at home," "Textbooks hard to understand," "Teachers too theoretical," "Wanting subjects I'm not allowed to take," etc., as well as problems concerned with The Future—Vocational and Educational: "Needing to decide on an occupation," "Not knowing what I really want," "Concerned over military service," "Deciding whether or not to go to college," etc. Typically, twelfth grade pupils exhibited about 75 percent knowledge of vocational trends and of the nature of the work involved in a sampling of representative occupations and a 67 percent knowledge regarding unfounded beliefs which lead to unfortunate vocational and educational choices.

So much for the 1947-48 studies which were variously conducted in 135 high schools. Copy for the inventories, tests, and schedules for conducting each of these studies has been set up in manual form. The manuals will be available on or about June 1.[7]

A fifth study in the series of studies basic to curriculum improvement, the Follow-Up Study, was initiated on February 15, 1949.

---

[7] Allen, Charles M., *How to Conduct the Holding Power Study*. Circular Series A, No. 51, Illinois Secondary School Curriculum Program Bulletin No. 3, Office of the State Superintendent of Public Instruction, Springfield, Illinois. May, 1949.

Hand, Harold C., *How to Conduct the Hidden Tuition Costs Study*. Circular Series A, No. 51, Illinois Secondary School Curriculum Program Bulletin No. 4, Office of the State Superintendent of Public Instruction, Springfield, Illinois. May, 1949.

Hand, Harold C., *How to Conduct the Participation in Extra-Class Activities Study*. Circular Series A, No. 51, Illinois Secondary School Curriculum Program Bulletin No. 5, Office of the State Superintendent of Public Instruction, Springfield, Illinois. May, 1949.

Lovelass, Harry D., *How to Conduct the Study of the Guidance Services of the School*. Circular Series A, No. 51, Illinois Secondary School Curriculum Program Bulletin No. 6, Office of the State Superintendent of Public Instruction, Springfield, Illinois. May, 1949.

This study is concerned with two problems, "How may we build a strengthened teacher-pupil-school-patron consensus regarding the 'need-meeting' function of the secondary school?" and "How may we appraise the extent to which the local school is, or is not, now meeting the real-life needs of its secondary-school youth?" The five instruments, each of the check-type, which were designed for use in this Follow-Up Study, and which are now being used in 100 schools, focus attention upon 55 real-life problems of youth variously subsumed under the categories of "Earning a Living;" "Developing an Effective Personality;" "Living Healthfully and Safely;" "Managing Personal Finances Wisely;" "Spending Leisure Time Wholesomely and Enjoyably;" "Taking an Effective Part in Civic Affairs;" "Preparing for Marriage, Home Making, and Parenthood;" and "Making Effective Use of Educational Opportunties."

Teachers, pupils, parents and laymen who are not parents are asked anonymously to indicate whether or not the high school should help pupils with each problem cited. If the response is in the affirmative, they are asked to state how important it is for the school to provide such help. Teachers are also asked to evaluate the extent to which they believe graduates typically received help on each problem. Graduates are requested to indicate which of the problems they are experiencing, how much of the help they needed for each problem they obtained in high school, and how effectively they believe they are meeting each problem.

In closing, I should like to state that the Illinois Secondary School Curriculum Program is truly grateful to the Academy for the attention it is giving in this program, and through other activities, to the improvement of the high school science program. Many of the findings that I have reported this morning are discouraging, but of this I am sure—if we all work together and cooperate with the teachers of other instructional areas—the situation will improve rapidly.

EVENING ADDRESS

TRAINING OF TEACHERS FOR TOMORROW'S WORLD

WILLARD B. SPALDING
University of Illinois, Urbana

Many persons in the profession of training teachers do not like to have the word "training" used to describe their activities. It is, however, an old term that has been used for decades. Currently many persons are endeavoring to replace it with the word "education." They do this because they see some connotations in the word "training" which they do not like, particularly when they think of training an animal or training an athlete. They think of a seal clapping his fins or of a boxer beating down an opponent. Neither idea seems to be related to the activities of the teacher in the classroom.

Before abandoning a long-used and well-understood term, we should look at some of the connotations of the substitute. An "educated" person is one who, in the common parlance, knows a lot about a lot. He is a person who has read widely, traveled widely, and experienced much. His skills are many, but rudimentary. He is somewhat of a dilettante.

A "trained" person is educated, of course, but he is also able to integrate his knowledge and his experiences around a single purpose. If he is a doctor, he integrates his knowledge toward curing the ills of the body. If he is an engineer, he integrates his knowledge toward the design and construction of machines, of structures, or of roads. This connotation of integration of knowledge to an end makes it important to retain the old term and to speak always of training teachers as we would speak of training any other professional person.

Change Inevitable

I have used the term "tomorrow's schools" because education inevitably looks ahead. The child who enters kindergarten in September of 1949 will graduate from high school in 1962, and from the university in 1966. What kind of world lies ahead of him? What problems must he solve when his schooling is ended? These are important questions for all of us, but especially important for those who train teachers.

Changes take place rapidly. There are great advances in technology. During the period of 16-17 years that lie ahead before the beginning kindergartener takes his place in adult life, a lot is going to happen. We can see this most readily by looking at the past before we look at the future.

We can go back to 1932 and compare what happened then with what happens now in 1949. There has been great development in electronics. Radar can detect mobile objects in the air and has many other uses. Television is just beginning to

have its impact upon American life. Great mathematical problems which could not be solved within available time are solved by so-called mechanical brains. All of these changes centering around electronics have taken place within the 17 years that have elapsed since 1932.

In the area of transportation, streamlined trains, just beginning to be heard of in 1932, are now common. There are new airplanes, like the flying wing, with jet propulsion engines that were not even widely developed in laboratories 17 years ago. Trains and trucks use the diesel engine which was not adapted for such use until recently.

In the area of communication, "Pocket Books" sell widely throughout all parts of the nation. We have seen the growth and development of picture magazines, the coming of age of talking pictures, and a beginning use of facsimile reproduction. These are but a few of the changes in material things which have affected our way of living.

In organized society, since the early days of 1932, there has come the growth of social security, old age pensions, the rise of the unions to power, and open attacks by governmental agencies on intolerance and prejudice. Our age is characterized by increased use of government in an increasing number of areas of human endeavor. Government yardsticks, for example, have been set up to measure private industry. Government planning enters more and more into the control of our physical environment and the direction of our activities as citizens.

These are the things which have gone on, but they tell us little about what changes lie ahead. The rate of both social and technological change is something like a geometric progression. The more that man knows about the physical nature of the universe, the more he can find out. The more and better material things he creates, the more he can create. The more that man improves his relationships with his fellows, the more he can do to improve them.

Attitude Toward Change

Man cannot predict exactly what is going to happen, but he can be sure that there will be tremendous speeding up in both technological and social change. He can also state with some certainty that the rate of technological change will continue to be somewhat greater than the rate of social change. The problem of lag in adaptation of our society to technology becomes increasingly acute. Man is reluctant to change his accustomed ways of doing. He doesn't seek to change his relationships to his government or to unorganized groups of his fellows with anything like the degree of eagerness with which he seeks to change his automobile when a new model comes out. He is reluctant to believe that the increasing speed of technological change makes social change not only inevitable but desirable. When he does begin to understand the need for social change, he does not translate his understanding into action.

As man observes the world, it is soon clear to him that there are competing systems of ideas about what is good in government, in the production of material things, and in the use and ownership of them. Ideas are not destroyed readily. The conflict of ideologies which exists today will continue through at least the

two decades which lie before us. It may differ in the degree of intensity with which it is carried on. It may change its nature somewhat, as new ideas come into the picture, but the conflict will remain.

Rapid technological change and rapid social change will be taking place in an atmosphere which is charged with the emotions arising from ideological conflicts. In the midst of the maelstrom sits the modern American, bewildered by what goes on and attempting to prevent many things from h a p p e n i n g. Change seems to him to be undesirable. He tends to resist it at every turn.

One of the great problems for education is the development of a generation of persons who understand that change is ordinary, who recognize that change is inevitable, who begin to examine their environment and to initiate changes in order to improve it.

One result of man's fearful attitude toward change is a change-resisting school rather than a school which facilitates changes. One of the major reasons for the critical social lag is the vicious circle in which one change-resisting generation makes the schools produce another change-resisting generation, which in turn prevents the schools from changing. Schools must recognize that a major responsibility is the development of an intelligent attitude toward change among their students, and this is not accomplished by teaching which reverently adheres to traditional, rote memorization procedures which fail to provide many opportunities for problem-solving.

Role of the Teacher

What is the role of the teacher in such a school? The teacher is several persons in one. First, he is a part of the environment of the children who attend school. His personality impinges upon the personalities of his students each day. What he does, what he is, what he thinks, how he dresses, how he appears, what he feels, and all of the other facets of his personality affect the way in which children learn what they learn.

In the second place, the teacher is a manipulator of the student's environment even while he is a part of it. He arranges the time of day at which each activity takes place. He selects and uses printed materials, pictures, and visual aids. He plans the emotional climate of the classroom. He decides whether there are to be democratic, autocratic, laissez faire, or some other kind of relationships.

In the third place, he is a scholar of the nature of society. He understands both social trends and social development. He sees cause and effect at work in human relationships and understands how to bring about the effects he desires. He is a student of the internal dynamics and structure of organized and unorganized groups of persons. He understands the ways in which governments operate.

In the fourth place, he is a scholar of the nature of man. He knows how man learns. He understands the physiology of human growth. He knows the relation of physiological readiness in learning. He understands the way in which attitudes, appreciations, and emotions are de-

veloped; in short, he understands with considerable thoroughness the human animal with which he deals.

In the fifth place, he is a professional person in a difficult area. The problems of the teacher are far more intricate and complex than those of any other profession. A human being cannot be placed in a test tube or a betatron and examined. He cannot be planted in the soil so that his growth and development can be watched. Whatever is done to him in order to observe him, changes him while the observing takes place. No technique can be used for long, because he adapts to it.

So it is with methods of teaching. It is extremely difficult to know what method of teaching is best in a given situation, and having found the method, it soon becomes obsolete. Man is an adaptive animal. Whatever is done to him leads to changes in his behavior so that he can escape from the doing. What is a good method with the student today may be a poor method with him three years later because he has learned to adapt to it. The teacher, as a professional, must know the methods which look to be good at the time that he is trained. He must also be versed in the procedures whereby he can invent better methods when he finds that familiar ones no longer work in practice.

Youth's Basic Needs

Unless the teacher may be characterized in these ways, he will achieve comparatively little success in helping *all* youth of secondary school age meet the sorts of basic needs which are outlined in the *Guide to the Study of the Curriculum in the Secondary Schools of Illinois*. An examination of any one of these youth needs will illustrate the complexity of the teacher's job. The fifth need cited is:

> Acquiring knowledge of, practice in, and zeal for democratic processes:
>
> a. Learning to be intelligently critical of the social heritage.
> (1) Possessing an understanding of and belief in our culture.
> (2) Being able to gather the facts regarding society and evaluating them.
> (3) Developing ability to be independent in arriving at judgments; must not merely imitate a teacher or leader.
> (4) Being able to propose a plan and see the consequences if the plan is adopted.
> b. Seeing and utilizing opportunities for participation in community activities outside of the school.
> c. Achieving appropriate understanding of and relationships with minority (or majority) groups.
> d. Developing an understanding of the necessity for international peace together with some knowledge of how to further it.
> e. Understanding relationships between the sciences and human destiny.

Training the Science Teacher

The scientists of America have studied the problem of training the science teacher. Their report was published in 1942. Participants in the project included the National Committee on Science Teaching, the American Council of Science Teachers, the American Association for the Advancement of Science, the American Chemical Society, the American Nature Study Society, the National Association of Biology Teachers, and several other scientific groups.

In discussing aspects of our present culture, their report states:

> There is likely to be little disagreement with the statement that our culture is witnessing one of the most rapid developments and changes in the history of Western civilization. There can be no quarrel with the proposition that

science—invention and technology—has been largely responsible for this unprecedented growth. Almost overnight, it seems, we have been whisked from an age of agrarianism and simple capitalism to an age of industrialism and corporate ownership. The change has been so rapid that we have not yet developed a terminology suitable for discussing with facility the new order of things. . . .

It is not to be wondered at, therefore, that there are at present many divergent ideologies. Nor is it surprising that men of science are becoming self-analytical, that scientists are attempting to develop critical philosophies, to understand the potentialities inherent in the methods and accomplishments of science. They recognize a responsibility, not only for their own immediate discipline, but also for the employment of their discoveries in the betterment of man's lot. . . .

Meanwhile the youth of today is facing a world of contradictions—of want in the midst of plenty, of fear in an age of potential security, of greed and selfish interest in a society supposedly influenced by the ethics of Christianity, of class stratification and restraint of human rights in a political democracy, and of wars and recurring crises in the "scientific" twentieth century. It is amid these confusions that the teacher of science must help young people solve their problems.

Aims of General Education

After describing these problems of our culture, the scientists then look at the problem of training a teacher, first, as an individual and a citizen:

The teacher is first of all a person. To the extent that he is intelligent, informed, conscious of social issues, and happily adjusted in his life and his views, he may become an outstanding teacher. This is true for all teachers regardless of field, and it should be noted that the general education proposed in this chapter is thought of in terms of *all* teachers and, for that matter, of all persons living in a democracy. But it seems especially important that those accepting the responsibility for giving science instruction be provided with this education.

The prospective teacher should acquire a sufficient range of understanding to insure his social acceptance in the community where he teaches. He should merit recognition as a person generally well informed and should be able to accept and handle a position of responsibility in the community.

He must have avocational interests and the ability to enjoy and appreciate a variety of intellectual and aesthetic pursuits. He must understand human beings, their customs, and their institutions, and recognize the roots of local prejudices and provincial mores in biological and cultural variants. To work effectively and sympathetically with community problems, he will need to recognize institutions in relation to their origins and in comparison with the similar and the greatly different institutions which have obtained in other times and places. And, above all, he should have had the advantages of guidance and study to aid him in the development of a personally and socially satisfactory conception of life.

I. THE TEACHER SHOULD HAVE AN UNDERSTANDING OF AMERICAN CULTURAL GROUPS. The American science teacher lives and works in the midst of a cultural complex composed of many shifting socio-economic, racial, ethnic, national, and religious groups. In times of crisis, intolerance, misunderstanding, and fear arise among cultural groups and these stresses are seized upon by demagogues and those seeking to further special interests. America, as well as Europe, is faced with fallacious doctrines and common misunderstandings regarding the superiorities or inferiorities of various groups. Most of these conclusions disregard the fact that range of individual difference within any population is demonstrably great with respect to almost any character; that to think of all individuals in terms of an average or in terms of other individuals is almost certain to result in error. Such conclusions convey the idea of political or racial units all of whose members possess given charcters.

II. THE TEACHER SHOULD UNDERSTAND THE VARIATIONS IN INSTITUTIONAL FORMS OF PAST AND PRESENT SOCIETIES. Today, more than ever before, it is imperative that those responsible for the education of youth defend and expand democracy and aid in actualizing our democratic vision. The science-trained teacher will recognize that the American forms of life can best be defended on the basis that they are operating in such ways that we de-

rive satisfaction, security, and personal and national well-being from them. Furthermore, they should be inspected and modified on the pragmatic basis of how well they are functioning, or can be made to do so, for the wellbeing of the nation and its individuals. . . .

III. THE TEACHER SHOULD UNDERSTAND THE POTENTIAL RELATION OF SCIENTIFIC RESEARCH TO DEMOCRACY. Society has already become so integrally scientific in the material sense that the expression, *impact of science on society*, is nearly meaningless. There is no aspect of human activity that organized science has not modified; but intellectually, we can hardly be called scientific. In large part science has remained subordinate to private interest and is called upon to do its part but to remain in the background; it is the indispensable handmaiden of our industrial expansion but could hardly be said at present to be offering intellectual direction to society commensurate with its potentialities.

IV. THE TEACHER SHOULD UNDERSTAND HIMSELF AND HIS STUDENTS, THEIR PARENTS, AND OTHERS IN THE COMMUNITY. That understanding of human beings is necessary for success as a teacher is a proposition likely to encounter little opposition. Basically it is the theme of every section in this chapter. This understanding is in part a background of general understanding of human beings, their characteristics, their development, and the factors which influence these. In part it is an understanding by the teacher of himself and the individual children and adults with whom he works.

V. THE TEACHER SHOULD DEVELOP LEISURE-TIME ACTIVITIES AND AESTHETIC SATISFACTIONS. It is the belief of the Subcommittee that the problems of leisure-time activities and the goal of developing aesthetic satisfactions should be more carefully considered in the education of teachers. The Subcommittee agrees with the statement that 'the word *(aesthetic)* should not only apply to something that happens in museums.'[1] Many take the position that teachers should have contacts with, and develop appreciations and abilities in, various areas of aesthetics. The National Survey of Education of Teachers revealed that only about one third of the teachers from teachers' colleges, liberal arts colleges, and universities had had any work at all in the fine arts in either high school or college.[2] Appreciation and creative ability in the arts need not, of course, originate or develop within the confines of institutions, but the establishments of early contacts may engender the development of appreciations and abilities which would otherwise remain dormant.

VI. THE TEACHER SHOULD DEVELOP A SATISFACTORY CONCEPTION OF LIFE. Many adolescents pass through a period of adjustment and orientation among conflicting religious and ethical concepts. Emotional disturbance often results when an individual experiences apparent contradictions between the faith to which he has clung and the logic that is associated with science. It seems important that the teacher, particularly the teacher who deals with the subject matter and the method of science, should be aware of the perplexities that exist in the minds of young people, and should develop for himself a consistent and workable philosophy of life that will enable him to give sound guidance and counsel to those in his charge.

These are the six aims of general education which scholars from scientific societies believe should become part of the aims for preparation of teaching of science. They should become part of the aims for the preparation of teachers for almost any field.

General education is related to the first aspect of being a teacher—that of being a part of the environment of the children in school, of being a personality which impinges at each moment upon the personalities of students. This education will enable them to develop the personalities which will be most helpful to them as individuals and citizens, and most wholesome for the students with whom they work.

[1] Progressive Education Assn., Commission on Secondary School Curriculum. *Science in General Education*, p. 126. D. Appleton-Century Co., New York, 1938.

[2] Evenden, E. S. *Summary and Interpretation: National Survey of the Education of Teachers*, Vol. 6, U. S. Office of Education. Government Printing Office, Washington, 1932.

Broad Versus Specialized Knowledge

A second area in teacher training deals with an area of specialization of knowledge with what he needs to know about the subject which he is going to teach. Before looking at this area, it is necessary to understand clearly what American schools are for. According to President Henry Hill of George Peabody College for Teachers:

> The purpose of the American high school, in the words of an Englishman who sees this more clearly than most of our college professors, is to provide such training and education and practice as seem necessary for the induction of all young men and women in the mores of the society in which they will move. To think that the chief purpose of the American high school is to produce scholarship is to make the whole matter ridiculous, and seriously interferes with getting on with the really fundamental, abiding, difficult problems before us.[3]

And again, from the report of the American Association for the Advancement of Science, we find the following statement:

> The majority of students in high school need the kind of science courses which fit their present interests and their future needs as citizens. Such courses must be well taught to be successful with thorough treatment of topics taken up and with application to consumer prob'ems, personal and public health, the use and conservation of natural resources, international relations and so on.[4]

This report goes on to state further that many colleges have adopted standards of concentration in the major department which make it difficult and often impossible for undergraduates to secure good preparation for teaching in as many as three sciences. While present standards may be appropriate for the future research scientist, they are not good for the future high school teacher. Colleges should provide opportunity for a concentration which shall not lie in one department but which shall spread not too thinly over at least three subjects in the sciences and mathematics.

These comments of the American Academy of Science are true of the preparation of teachers in almost every area. The typical curriculum of a large university or liberal arts college is directed toward the training of specialists and not toward the training of high school teachers. The course offerings which are presented point toward the preparation of individuals who know more and more about less and less. They do not include the broad general problems of a whole field. They may be necessary to produce persons capable of scholarly research and the advancement of knowledge, but there should be some way to select these individuals, and to educate them separately. As Henry Hill has said:

> Our attempt 'to educate everybody' is unique in world history. It is perhaps more an education involving attitudes, and emotions and skills than scholarship and intellect. I have always seriously doubted whether as many as five per cent of the earth's inhabitants had either the capabilities or the interest to become scholars.[5]

It is about time that institutions of higher education recognized this hard fact of life and set up an educational program which would enable scholars to move ahead and, at the same time, enable those who are not scholars to receive the broad, rich education within any subject matter field which will make them

[3] Hill, Henry H. "The Teacher Must Learn His Craft." *The Peabody Reflective*, March, 1949, p. 83.

[4] American Association for the Advancement of Science, Cooperative Committee on Science Teaching, mimeo., 1946, p. 109.

[5] Hill, Henry H. "The Teacher Must Learn His Craft." *The Peabody Reflective*, March, 1949, p. 83.

far better citizens and far better teachers than any of us.

What the prospective teacher needs is broad knowledge in a subject matter field rather than highly specialized knowledge. He needs to be trained within any area so that he understands its broad scope and its interrelationships. Only this training will enable him to acquaint students with its scope and relationships.

Social Culture

The third area in which a teacher must be trained is in that of understanding the nature of society. Much of what has been mentioned earlier under general education fits in here, and I will not dwell upon it further, but merely repeat that it is an area which needs attention.

Human Nature

The fourth area is that of training in the nature of man. It is here that anthropology, sociology, and most particularly psychology should make great contributions. The teacher must have a thorough grounding in the nature of human nature, in the human sciences, so that he will understand how man ticks, what makes him tick, and how to make him tick in different ways.

Professional Methods

A fifth area of education is related to the manipulation of the environment by the teacher. It is the field of professional methods of teaching. These should come late in the education of the teacher, but they should arise out of constant and continuous observation of schools in action, out of the study of the nature of human nature, and out of the nature of society. It is frequently assumed that methods are related to what is taught rather than whom is taught. Colleges and universities multiply methods courses incredibly. There are methods of teaching arithmetic, methods of teaching algebra, methods of teaching mathematics, methods of teaching biology, methods of teaching chemistry, methods of teaching French, methods of teaching Latin, and so on and on, down through the long list of subjects that are offered in the typical American high school. Nowhere do I know of a course in methods of teaching students, yet they, and they alone, are taught.

Methods of teaching, while they may be accepted verbally, become effective only as they are practiced. There must be long and continued opportunities for prospective teachers to do this under the observation of master teachers who can give them criticism, advice, and assistance.

An intensely practical reason for modifying teacher training programs in these ways stems from the very vigorous activities of the Illinois Secondary School Curriculum Program. If I am any judge of what is happening, the schools are developing programs which will call for teachers who must, if they are to be successful, possess training of the type described.

Summary

In summary, the training of teachers is a complex and difficult task. If it is to be effective, it must produce an individual whose knowledge is integrated toward helping students to learn. It must produce persons who are aware of the need for

change, and who seek to develop this awarness in others. To do this, it makes use of broad general education in order that teachers may have desirable personalities. It includes subject area courses which are directed toward an understanding of people and relationships. It includes thorough grounding in the human sciences. It includes long practice in using methods of teaching students.

I have attempted to indicate what, in my judgment, might be a better program for training teachers for tomorrow's schools. One of the more intangible, but most important, attributes of the superior teacher has been left until the last for purposes of emphasis—the terribly urgent need for a better citizenry which comes from the great social problems of tomorrow. When these problems are enhanced in complexity and danger by atomic energy, they cannot be met by skill and competence alone. A deep and abiding sense of the importance of teaching must be left within the heart and mind and spirit of each graduate. There must, of course, be love for children, affection and respect for fellow teachers, a desire to secure increasingly greater competence and belief in the essential human values of democracy.

These are important, but of themselves they are not enough. They must be coupled with a fierce determination, a kind of missionary zeal to make the world a better and a safer place for man because of what is done in school. Developing this spirit is the great task of every institution which is training teachers. In it, we cannot and we will not fail.

PROGRAM FOR THE 42nd ANNUAL MEETING
PAPERS PRESENTED

ARCHAEOLOGY AND ANTHROPOLOGY

C. C. BURFORD, *Chairman*
Urbana

*1. More Data on the Hopewell in the Peoria Region: Ethel Schoenbeck, Peoria.
2. Folsom Points in Illinois: William Smail, Loogootee.
3. You Can Still Find Them: Dr. Dan Morse, Peoria.
4. News and Comments—The Contemporary Archaeological Picture: Claude U. Stone, Peoria.
5. The New Building, Illinois State Museum: Thorne Deuel, Springfield.
6. Sauk and Fox Indian Ceremonials, Black Hawk State Park, Rock Island, Illinois: John H. Hauberg and Russell P. Neuwerk, Rock Island and Moline.
7. Ceramic Series in the Illinois River Area: John C. McGregor, University of Illinois, Urbana.
*8. The Non-Mississippi Manifestations at the Fisher Site: Charles E. Gillette, University of Chicago, Chicago.
9. Results of Two Seasons of Archaeological Work in the Starved Rock Area: Graduate Students, Department of Anthropology, University of Chicago, Chicago.
   A. Introduction: Kenneth G. Orr.
   B. A Non-Pottery Manifestation: William Mayer-Oakes.
   C. The Earlier Woodland Manifestations: Elaine Bluhm.
   D. Possible Interrelations of the Healy and Fisher Manifestations: Molly Allee.
   E. The Fort Ancient Manifestations: Gordon Keller.
   F. Problems of the European Occupation: Richard S. Hagan.
   G. Significance of the Cultural Stratigraphy: Kenneth G. Orr.
10. Pictures of Archaeological, Historical, and Scenic Locales in Southern Illinois: Irvin Peithman, Carbondale.

BOTANY

R. M. MYERS, *Chairman*
Western Illinois State College, Macomb

*1. Initial Report on the Vascular Plants of Southern Illinois: Wm. M. Bailey, Southern Illinois University, Carbondale.
2. Sanctuaries: Jens Jensen, The Clearing, Ellison Bay, Wisconsin.
*3. The Ferns of the Rock River Valley in Illinois: E. W. Fell and George B. Fell. Junior author, U. S. Soil Conservation Service, Rockford.
*4. A Checklist of the Vascular Plants of Winnebago County: George D. Fuller, E. W. Fell. and George B. Fell. Senior author, Illinois State Museum and University of Chicago,
5. Antibiotic Studies with Verticillium albo-atrum: L. R. Tehon and J. C. Carter, Illinois State Natural History Survey, Urbana.
*6. Embryo Development of the Pond Cypress (Taxodium ascendens Brongn.): Margaret Kaeiser, Southern Illinois University, Carbondale.
7. The Ralph Emerson Preserve, Rockford, Illinois—an Outdoor Botanical Laboratory for Rockford College: Evelyn I. Fernald, Rockford College, Rockford.
8. Intra-inbred Selections in Maize: O. J. Eigsti, Northwestern University, Evanston.

* Published in this volume.

CHEMISTRY

W. P. CORTELYOU, *Chariman*
Roosevelt College, Chicago

1. Decomposition Potentials to Identify Sugars: G. W. Thiessen and Vada Treloar Tschaepe, Monmouth College, Monmouth.
2. The Periodic Chart and the Total Number of Elements: Frank O. Green and Bernard S. Jackson, Wheaton College, Wheaton.
3. Report on the New National Cooperative Undergraduate Chemical Research Program: E. H. Cortelyou, Illinois Institute of Technology, Chicago.
4. Factors Influencing Undergraduates Research: Ward V. Evans, Frank P. Cassaretto, and Theodore G. Klose, Loyola University, Chicago.
*5. The Place of Science in General Education: Sister Mary Marguerite Christine, BVM, Mundelein College, Chicago.
6. Seminar—The Future of the Chemistry Section of the Illinois Academy of Science: Panel Discussion. Speakers to be announced.

GEOGRAPHY

JOHN F. LOUNSBURY, *Chairman*
Northwestern University, Evanston

1. The Panama Canal Scheduled for a Major Operation: W. O. Blanchard, University of Illinois, Urbana.
2. Geographic Aspects of the New Political Structure of India: Alfred W. Booth, University of Illinois, Urbana.
3. The German Potash Industry and its Recent Development: Vernon Brockman, Northwestern University, Evanston.
4. A preliminary Investigation of the Population Cluster in the Lake St. John-Saguenay Valley: Voris V. King, Illinois State Normal University, Normal.
5. Developments in Finland's Economy Brought About by World War II: Lauri J. Niemuela, Northwestern University, Evanston.
6. Polar Eskimos of Greenland and Their Environment: William E. Powers, Northwestern University, Evanston.
7. The Russian Doukhabors in West Kootenay, British Columbia: Malcolm E. Robinson, Northwestern University, Evanston.
*8. The Pulp and Paper Industry in the Lake States—A Study in Industrial Location: L. Majorie Smith, Northwestern University, Evanston.
9. Transportation into the Fountain Square Shopping Center of Evanston, Illinois: Jack A. Bradley, Evanston Community College, Evanston.
10. The Illinois Coal Market: Willis L. Busch, Illinois State Geological Survey, Urbana.
*11. Occupance of the Southern District of Southern Illinois: John H. Garland, University of Illinois, Urbana.
12. The Calumet Area Industrial Terminal: Nina T. Hamrick, Illinois State Geological Survey, Urbana.
13. The Climatic Regions of Illinois: John L. Page, University of Illinois, Urbana.
14. Relationships of Southern Illinois Orchards to Physical Factors: Dalias A. Price, Southern Illinois University, Carbondale.
15. Farm Management and Conservation in DeKalb County, Illinois: Martin W. Reinemann, Northern Illinois State College, DeKalb.

GEOLOGY

PERCIVAL ROBERTSON, *Chairman*
Principa College, Elsah

*1. The Present State of Knowledge Regarding the Pre-Cambrian Crystallines of Illinois: Robert M. Grogan, Illinois State Geological Survey, Urbana.

* Published in this volume.

*2. Facies Analyses of Niagaran Rocks in Illinois: H. A. Lowenstam, University of Chicago, Chicago.
3. The Late Cenozoic History of Southern Illinois: Morris M. Leighton and Harold B. Willman, Illinois State Geological Survey, Urbana.
*4. Physical Characteristics of the Oolite Grains of the Ste. Genevieve Formation: Raymond S. Shrode, Illinois State Geological Survey, Urbana.
5. Scenic Geology of Southern Illinois Ozarks: L. O. Trigg, Eldorado.
*6. Factors Affecting Laboratory Measurement of Permeability of Unconsolidated Glacial Material: Robert D. Knodle, Illinois State Geological Survey, Urbana.
7. Geological and Geophysical Studies of the Glacial Groundwater Aquifers in the Champaign-Urbana Area: Merlyn B. Buhle and John W. Foster, Illinois State Geological Survey, Urbana.
8. The Warsaw Formation in the Subsurface of Western Illinois: Donald B. Saxby, Illinois State Geological Survey, Urbana.
9. The Neda Iron Ore in Northeastern Illinois: L. E. Workman, Illinois State Geological Survey, Urbana.

PHYSICS

A. FRANCES JOHNSON, *Chairman*
Rockford College, Rockford

1. Some Problems in Low Temperature Physics: Lester I. Bockstahler, Northwestern University, Evanston.
*2. Investigation of a Gamma-Proton Process in Beryllium: Richard L. Conklin, University of Illinois, Urbana.
3. Neutron Cross-section Measurements at the Argonne Chain-reacting Pile: D. J. Hughes, Argonne National Laboratory, Chicago.
4. The Modern Teaching of Modern Physics—A Proposal: O. L. Railsback, Eastern Illinois State College, Charleston.
5. Microwave Diathermy: Julia F. Herrick, Mayo Foundation, University of Minnesota, Rochester, Minnesota.
*6. A Simple Circuit for Measuring Variations in Electrical Resistance of a Human Being Under Emotional Stress: A. F. Silkett and Mae A. Driscoll, University of Illinois, Navy Pier, Chicago.
7. Physics Applied to Watchmaking: C. N. Challacombe, Elgin National Watch Company, Elgin.
*8. Electronic Aids to Control and Measurement: Howard C. Roberts and Richard E. Wendt, Jr., University of Illinois, Urbana.
9. Quantitative Experiments on Normal and Oblique Precession: Philip A. Constantinidies, Wilson Branch Chicago City Junior College, Chicago.
10. The Role of Stops in Simple Optical Systems: Lee W. Gildart, Northwestern University, Evanston.
11. Some Factors in Determining a Student's Grade in a Science Course: Paul E. Martin, Wheaton College, Wheaton.
12. A Semantic Approach to the Elementary Laboratory: Andrew Longacre, University of Illinois, Urbana.

PSYCHOLOGY AND EDUCATION

D. M. HALL, *Chairman*
University of Illinois, Urbana

Theme: Developmental Projects in Science Education in Illinois Schools.
1. The Role of Science in the Common Learnings Program: Louise Riddle, Oakwood Township High School.
2. What we are doing in Biological Science: Charlotte Grant, Oak Park Township High School, and F. G. Weber, West Senior High School, Rockford.
3. What we are doing in Physical Sciences: Ralph Edwards, Streator Township High School, Streator, and Robert F. Seamon, University High School, Urbana.

* Published in this volume.

4. Panel Discussion: The Implications for Teacher Training.
R. Will Burnett, Professor of Education, University of Illinois, Urbana.
Bjarne Ullsvik, Professor of Mathematics, Illinois State Normal University, Normal.
John D. Mees, Principal and Instructor in Biology, University High School, Southern Illinois University, Carbondale.
L. Wallace Miller, Professor of Biological Science, Illinois State Normal University, Normal.
T. A. Nelson, Instructor in Chemistry, Lyons Township High School and Junior College, LaGrange.
R. F. Paton, Professor of Physics, University of Illinois, Urbana.

SOCIAL SCIENCE

LYNFORD A. LARDNER, *Chairman*
Northwestern University, Evanston

1. An Integrated Approach to Industrial Problems: Donald E. Wray, University of Illinois, Urbana.
2. Problem of the Sociology of Knowledge: Godfrey Delatour, Visiting Professor from Columbia University at the University at Illinois, Urbana.
3. Rationalism, Empiricism, and Sociology: Robert Bierstedt, University of Illinois, Urbana.
4. Some Problems of Methodology in Anthropology: Oscar Lewis, University of Illinois, Urbana.
5. An Evaluative Study of the Group Work Process in an Interstitial Urban Area (Chicago's West Side): LeRoy L. Kohler, Bradley University, Peoria.
*6. The Structure and Institutionalization of a Protest Group: F. E. Houser, Wheaton College, Wheaton.
7. Comments on the Current Work of the Illinois State Revenue Laws Commission: Vernon G. Morrison, Southern Illinois University, Carbondale.
*8. Southern Illinois, A Cultural Area: William J. Tudor, Southern Illinois University, Carbondale.

ZOOLOGY

JAMES M. SANDERS, *Chairman*
Chicago Teachers College, Chicago

1. Problems of the Small Animal Colony: Bertrand A. Wright, The Armour Laboratories, Chicago.
2. Robert Kennicott and the Chicago Area Herpetofauna: Albert G. Smith, Loyola University, Chicago.
*3. A Survey of the Unionidae of the Upper Reaches of the Mackinaw River: Garwood A. Braun, University of Illinois, Urbana.
*4. Genetic Variation in Populations of Drosophila melanogaster in the Chicago Area: Sidney Mittler, Illinois Institute of Technology, Chicago.
5. Data on the Sex-biology of Two Arionid Slugs: Glenn R. Webb, University of Illinois, Urbana.
*6. Parasites of the Ranidae (Amphibia) XIV: A. C. Walton, Knox College, Galesburg.
7. Arthropods of Medical Interest Collected in the Mediterranean Area (An Annotated List): Garland T. Riegel, Eastern Illinois State College, Charleston.
8. Effects of Orchidectomy in Golden Hamsters: Willis E. McCray and Charles L. Foote, Southern Illinois University, Carbondale.
9. Some Instances of Diapause among Insects: W. V. Balduf, University of Illinois, Urbana.
*10. Notes on the Biology of a Common Gastrotricha of the Chicago Area, Lepidoderma squmatum (Dujardin): Robert J. Goldberg, Chicago City Junior College, Chicago.
11. A Quantitative Study of the Relation between the Resting and Acting Potential of the Frog Eye: Stewart W. Freyburger, University of Illinois, Urbana.
*12. Incidence of Trypanosoma Infection in Small Rodents of Champaign County, Illinois: Russell E. Nelson, University of Illinois, Urbana.

* Published in this volume.

COLLEGIATE SECTION

HARRY J. FULLER, *Coordinator*
University of Illinois, Urbana

CAROLE WILHELMI, *Chairman*
College of St. Francis, Joliet

A—BIOLOGICAL AND SOCIAL SCIENCES

1. Most Common Rotifera of Lake Michigan Collected in the Chicago Area: Wilma Lehman and Frances Fazio, Mundelein College, Chicago.
2. Experiments in Embryonic Development of a Chick: Willye Thomas, College of St. Francis, Joliet.
3. A Technique for Anaerobic Methods: Joseph Gray, Northwestern University, Evanston.
4. Variation of the Quantity of Nucleic Acid in the Tissues of Drosophila at Different Ages: Mary Russel, Mundelein College, Chicago.
5. The Anatomy of Molgula: Joseph Fisher, Loyola University, Chicago.
6. Variations of the Quantity of Nucleic Acid in the Tissues of Oxalis at Different Ages: Virginia Dineen, Mundelein College, Chicago.
7. Asthma Brought Up to Date: Margeurite Bonner, College of St. Francis, Joliet.
8. Nuclear Apparatus of Various Oxytrichidae (Ciliata, Hypotricha) at Different Stages of Their Life Cycle: Mary Joan Kornetzke and Marilyn Tucker, Mundelein College, Chicago.
9. Improved Methods of Activating Tapeworm Embryos: Shirley Nice, Monmouth College, Monmouth.
10. Simplified Photomicrography with the Hand Camera: Frank Fitch, Monmouth College, Monmouth.
11. Embedding Biological Specimens in Plastics: Janet Boles, Monmouth College, Monmouth.
12. Hemoglobin Percentages in College Students in the Spring Compared with Early Fall Readings: Jane Martin, Monmouth College, Monmouth.

B—PHYSICAL AND EARTH SCIENCES, AND MATHEMATICS

1. The Glacial Geology of Otter Creek Area, Jersey County, Illinois: E. Gene Smith, Principia College, Elsah.
2. Medical Application of Radioactivity: Anne Bannon, College of St. Francis, Joliet.
3. Results of a project for the Volumetric Determination of Bismuth: Bruce Kirkman, Southern Illinois University, Carbondale.
4. A Study of the Porphyrin-like Substances in Fresh Horse-Radish: Rosemary Legenza and Vivian Walkosz, Mundelein College, Chicago.
5. Codeposition of Zinc and Iron: Douglas S. Fairgrieve, Principia College, Elsah.
6. Titration of Periodate: William Ulrich, Southern Illinois University, Carbondale.
7. Isolation of Certain Compounds from Green Leafy Vegetables by Chromatographic Methods: Paper presented by Mary Lou Killey, College of St. Francis, Joliet. (Research by the speaker and Jane Dilger, Mary Virginia Morse, Lorraine Sporar, and Shirley Vescovi, College of St. Francis, Joliet.)

* Published in this volume.

ARCHAEOLOGY AND ANTHROPOLOGY

LATE WOODLAND OCCUPATIONS OF THE FISHER SITE, WILL COUNTY, ILLINOIS

CHARLES E. GILLETTE
University of Chicago, Chicago

The Fisher Site is situated on the south bank of the Des Plaines River about a mile upstream from where it joins the Kankakee to form the Illinois River. The site originally consisted of twelve burial mounds and a series of probable house pits. Throughout the site there occur burials which show no cultural affiliations, and therefore are not considered in the study.

In 1906 George Langford began his diggings at this site and found it to be of sufficient importance to be of interest to midwestern archaeologists. His work on the site continued intermittently until 1929. He subsequently gave his materials and notes to the University of Chicago, where they have formed the basis of further research and study of the Fisher Site.

In the two larger mounds Langford found definite evidences of stratigraphy. Each mound was divided into three levels, the upper, the middle, and the lower. The upper and middle levels were each separated from the one beneath by a dark seam, which he interpreted to be old ground surfaces. The depth of burial was not significant, but the relative age could be determined by tracing the burial fill to one of the three levels, and determining if either or both of the black seams had been pierced.

In the lower level Langford found burials without artifacts. He subdivided this level into two parts, on the basis of burial type and fill. Some were carefully flexed burials lying on the left side with grave fill indistinguishable from the surrounding gravel. This fact led him to call them "concealed burials." The other burials in the lower level were "sprawling" in position, lacking orientation or any semblance of planned arrangement. In these the grave fill was very slightly discolored by black soil, and he called them "semi-concealed." In all cases where the "concealed" and the "semi-concealed" burials were found in close association with each other, the former were always beneath.

In the middle level Langford found extended burials with grave goods. Although much of the material is very similiar, he was able to separate them into two groups on the basis of pottery differences. One group is marked by a decorated shell-tempered pottery, whereas the other group is marked by a less elaborate grit-tempered pottery decorated with many of the same motifs found on the shell-tempered ware.

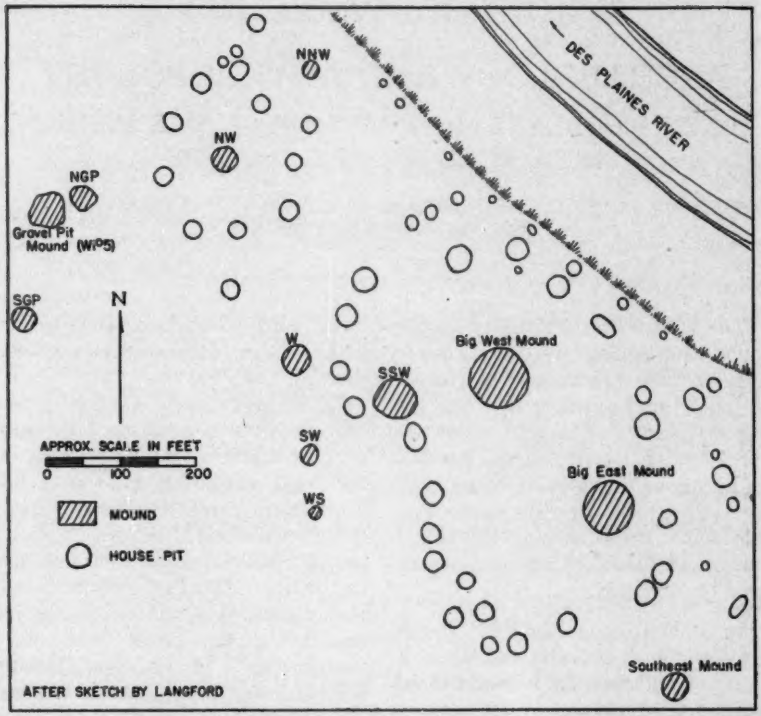


FIG. I.—Relative locations of features of the Fisher Site.

The problems of the upper level are based, for the most part, on the inability of the excavators to ascertain the stratigraphy within this level. The burials are found in many positions, some with and some without artifacts. Langford distinguishes three different cultural horizons within this level. One is marked by a grit-tempered unornamented pottery, quite similar to the grit-tempered ware of the middle level. The second is a Late Woodland horizon marked by stray sherds and stemmed projectile points that are apparently present in the fill, rather than associated with the burials. The third is an Historic horizon which has no pottery, and is marked by trade materials of European origin, and in some cases, flint projectile points and shell beads of Indian manufacture.

Langford arbitrarily typed the materials from all of the other mounds and the pits on the Fisher Site, using as his pattern the stratigraphy and typology which he found in the two big mounds, as described above. His Gravel Pit Mounds, where he found a concentration of what he called Late Woodland, and his Southeast Mound where he found a concentration of the Historic, were dated as the last occupations of the

site, since they showed similarities to two horizons of the upper level of the large mounds.

In 1946 John W. Griffin studied Langford's material and notes and selected for consideration two types of pottery, one with shell temper and one with grit temper, both with clearly defined Upper Mississippi affiliations. These he subjected to further intensive study and found that they fell into three periods. *Period A* included the decorated shell-tempered ware, *Period B* included the decorated grit-tempered ware, and *Period C* included the undecorated grit-tempered ware. He considered this to be their chronological sequence, which was also Langford's conclusion on the Upper Mississippi material. The complete findings of Griffin's study are found in his master's thesis, University of Chicago, 1946.

In 1940 a joint expedition of the Illinois State Museum, the University of Chicago, and the W.P.A. entered the field under the direction of Gretchen Cutter Sharp. This expedition was particularly interested in the relationships of Late Woodland and Historic materials to the other manifestations on the site. So far the results have been published in only one article (Deuel, 1940). The present paper is concerned with a more intensive study of the same problem.

The Late Woodland manifestation on the Fisher Site is identified with pottery having the following characteristics: Grit temper, cord marking, reddish paste, jar form with rounded bottom, and ranging from low to hard firing. It occurs with and without a collar, with and without castellations, with and without a definite shoulder, and with and without notched lips. Lip notching was done with either plain or cord wrapped stick. Most examples have round mouths, but some occur with angular openings. The thickness ranges from 3.2 mm to 8.3 mm. No lugs, handles, or other appendages have been found. Decoration seems to be limited to punctates in parallel lines between the neck and shoulder. Langford reports two examples of parallel single cord impressions, but these sherds are not available for study.

In the current study, the sherds found in the Gravel Pit Mound Wi°5 were analyzed and the Late Woodland pottery arbitrarily divided into six classes.

Class I

One reconstructed pot and several sherds are characterized by low firing, angular mouth, flaring rim (slightly thickened below the lip to give the effect of a collar), the general lack of a defined shoulder, and a relatively small size.

Class II

One reconstructed pot and several sherds have vertical rims, thickened below the lip to form a collar. This thickening is apparently due to a folding of the rim. It has a clearly defined shoulder and a characteristic change in direction of paddling at the shoulder. Above the shoulder the paddling is vertical, and below it it is diagonal. These pots are generally larger in size than Class I.

Class III

The sherds in this group indicate pots small in size, with thin walls,

and without collars. There is considerable variety in all other characteristics.

Class IV

One large sherd is separated into this group by its similarity to Tampico pottery in its rim and shoulder form, and it is smaller in size than Class I and Class II.

Classes V and VI

These two classes show variations in decorative treatment. Class V sherds have parallel lines of punctates on the shoulder, while Class VI sherds have horizontal lines of single cord impressions.

There were 415 Woodland sherds found in Wi°5. Because of the great homogeniety of the Woodland body sherds, and their close resemblance to the body sherds of the Langford Corded (*Period B*), this classification is based upon the variations found in the rim and shoulder treatment of 73 rimsherds, 51 from Wi°5, and 22 from the Village Area. These six classes constitute the pottery of the Des Plaines Complex, which is a variant of the Tampico Phase.

There are two evidences on the site that this Late Woodland pottery may be present at an earlier time than has heretofore been suspected. Langford indicated in a cross section that the upper level of the larger mounds was a grey-brown earth, but that the middle level was a brown earth. The stratigraphy of Wi°5 is apparently similar to that of the two larger mounds—upper and middle levels divided by a black seam. Examples of the Late Woodland pottery have been found definitely beneath the black seam in Wi°5, in a brown earth stratum. In a test trench pit, both types of soil were present, but the Woodland sherds were in the brown earth which lay at the bottom of the pit. This would seem to indicate contemporaneous existence with Langford's middle level, based on the similarity of the soil.

Another indication of a probable earlier time level for this Late Woodland pottery is burial East Mound 21 This burial is in the big East Mound, and had associated with it a pot similar to those of Class III. Langford describes this burial as follows: "This excavation gave a fine wall section showing the black seam undisturbed three feet below the mound surface. One and one-half feet below that was a thin dark seam over a five inch ash and dirt layer, and then another seam. The grave had been dug through the ash layer and the lower seam, but the upper seam was intact." This places it definitely in the middle, or brown earth stratum of the big East Mound, and indicates the coexistence of this Late Woodland type pottery with John Griffin's *Period A* pottery (shell-tempered Upper Mississippi) and his *Period B* pottery (decorated grit-tempered Upper Mississippi) because they all occur in the same soil stratum.

The major portion of the Late Woodland pottery found on the site is found in Wi°5. It seems to appear as mound fill, and is not associated with the burials in the mound. One pot, which has been reconstructed, was found scattered over an area fifteen feet by twenty feet, and above and below the black seam, where it had evidently been carried by intrusive digging. Other sherds are

similarly scattered over a wide area, both horizontally and vertically. Any reconstruction usually contained pieces from more than one square and level. The fact that sherds are found in the fill closely associated with undisturbed burials indicated that this pottery antedates the burials, and probably the mound itself.

Associated with the burials in this mound are artifacts, including bone harpoon points, and other bone and stone objects, whose cultural affiliation is at present unknown but they show similarities to Owasco.

Let us now consider the cultural affiliations, in the Illinois area, of the Late Woodland pottery at this site. Collared pottery with an angular mouth similar to Class I is found at the Corbin Site, at the Salt Well Site, at the Old Hotel Plaza Site, all in the Starved Rock area. Ethel Schoenbeck has reported a sherd similar to this type from the Clear Lake Site in Tazewell County (Schoenbeck, 1946, p. 389) and Barrett also reports them as present in the Azatlan material in Wisconsin (Barrett, 1933, pp. 319-20).

The pottery with the round mouth and vertical rim (Class III) is similar to that found in the Gooden Mound in Fulton County (Cole and Deuel, 1937, p. 116), at the Mills Village Site in Joe Daviess County (Bennett, 1945, plate 30), and in the Azatlan material from Wisconsin (Barrett, 1933, pp. 308-10). Similar materials found at the Boulder Site in Clinton County are classed by Elaine Bluhm as belonging to the Dillinger Focus (Bluhm, 1948).

In summary we may say that the Late Woodland manifestation at the Fisher Site seems to be a post-Hopewellian development. The Late Woodland of this particular type has to date been found only in the Illinois Area. It has definite relationships to both the Dillinger Focus and the Maples Mills Focus. The pottery shows a definite influence from the Monks Mound Aspect of the Middle Mississippi Phase. It has in turn influenced the Langford pottery, where its peculiar styles of grit tempering, cord marking, folded rim, and lip notching may be traced as survivals.

REFERENCES

Barrett, S. A. 1933—"Ancient Azatlan," *Bulletin of the Public Museum of the City of Milwaukee*, Vol. XIII.

Bennett, J. W. 1945—*Archaeological Explorations in Joe Daviess County, Illinois*, University of Chicago Press, Chicago.

Bluhm, Elaine A. 1948—"An Analysis of Boulder Sites: A Study of Early Hopewell Occupations in Illinois," Unpub. M. A. Thesis, University of Chicago.

Cole, Fay-Cooper, and Thorne Deuel. 1937—*Rediscovering Illinois*, University of Chicago Press, Chicago.

Deuel, Thorne. 1940—"Archaeological Field Work of the Illinois State Museum," *Quarterly Bulletin of the Illinois State Archaeological Society*, Vol. III, No. 1.

Eggan, Fred K. 1932—"Archaeology of Will County," *Transactions, Illinois Academy of Science*, Vol. 25, No. 4.

Griffin, J. B. and R. G. Morgan. 1941—"Contributions to the Archaeology of the Illinois River Valley," *Amer. Philosophical Society Transaction*, Vol. XXXII, No. 1, pp. 1-209.

Griffin, J. W. 1944—"New Evidence from the Fisher Site," *Transactions, Illinois Academy of Science*, Vol. 25, No. 4.

1946—"The Upper Mississippi Occupations of the Fisher Site, Will County, Illinois," Unpub. M. A. Thesis, University of Chicago.

Krogman, W. M. 1931—"Archaeology of the Chicago Area," *Transactions, Illinois Academy of Science*, Vol. 23, No. 3.

LANGFORD, G. L. 1927—"The Fisher Mound Group, Successive Aboriginal Occupations Near the Mouth of the Illinois River," *American Anthropologist*, Vol. 29, No. 3.
1928—"Stratified Indian Mound in Will County," *Transactions, Illinois Academy of Science*, Vol. 20.
1930 —"The Fisher Mound and Village Site," *Transactions, Illinois Academy of Science*, Vol. 22.
MAXWELL, MOREAU. 1946—"A Designation of the Dillinger Focus," Unpub. M. A. Thesis, University of Chicago.
SCHOENBECK, ETHEL. 1946—"Cord Decorated Pottery in the General Peoria Region," *Transactions of the Illinois Academy of Science*, Vol. 39.

MORE DATA ON HOPEWELL SITES IN PEORIA REGION

E. SCHOENBECK
Peoria Academy of Science, Peoria

This paper gives a preliminary list of objects found at the Rench Village site, north of Mossville, and gives a few comparisons with collections from the Clear Lake and Steuben village sites, all Hopewell sites of the general Peoria region. It also reports several unrecorded items from Clear Lake and Steuben sites. Collections were made by Anson M. Simpson, and by Mr. and Mrs. George Schoenbeck, members of the Peoria Academy of Science.

Rench Village Site

Rench Village, listed as site No. 3 in the Peoria Academy survey, is about four miles north of Mossville, Peoria County, in Medina Township, sec. 15, T. 10 N., R. 8 E. It consists of about 20 acres of flat bottomland at the base of the bluff and north of Dickison Run, a small creek. It is part of the farm owned by Mrs. Bertha Purcell of Mossville, occupied by Floyd Rench, and present use includes plowed fields, a vegetable garden, and a chicken yard. Indian mounds are located on the Sturm property on the bluff north of the Rench Village site. The Dickison Mounds are about two miles to the east and the Mossville Village site is about three miles to the south.

The village and mounds were visited by Fay-Cooper Cole and a group from the University of Chicago in 1941. Survey sheets are in the files of the University of Chicago and the Illinois State Museum at Springfield. A brief report on the site, by A. M. Simpson, was given at the 1944 meeting of the Illinois Academy of Science at DeKalb, Illinois.

It has been reported that the owner made an early collection of material from the Rench Village site which he sold to a Peoria dealer. Simpson made his first collection in 1937. The Schoenbecks joined in surface collecting the same year, and several years later undertook a limited amount of excavating. About fifty trips have been made, the last of which was on May 1, 1949. Other collectors from the Peoria Academy of Science include Leroy Elliott, Virginius Chase, Bob Poehls, Almon Buis, Dr. Dan Morse, and D. Morse, Jr.

Excavations have covered an area of perhaps 120 square feet to a depth of about 5 feet—a limited area in comparison to excavations at Clear Lake. The upper depth was mostly bare of material, but several burials were found, and scattered among the village debris were human bones, including skulls and jaws. One skull was found by itself; there was one partial skeleton of a human embryo. At another location one adult burial occurred at a depth of only 18 inches, with village material all around. A thin rough slab of stone, four to five inches in diameter, lay beneath the skull.

Part of the skeletal material from Rench Village, together with material from Clear Lake and Sister Creek

Photograph by Barclay Photo Co.

RENCH VILLAGE SITE

FIRST ROW:
Rim of Bossed, Channeled, "Brushed" pottery.
Sherd of polished, thin, limestone-tempered Hopewell pottery with "brushed" marks in the zoned areas.
Rim of thin, polished Hopewell with "brushed" marks placed horizontally.
Rim of polished gray, incurved, similar to Marksville Plain.
Shell spoon, with hinge removed.
Shell hoe, perforated.

SECOND ROW:
Types of points.

THIRD ROW:
Pendant.
Pipe bowl, highly polished.
Stone artifact, with polished tip.
One-half of polished stone ball.
Copper bead or bangle.
One-half pendant, unfinished, with two perforations—one from each side but not meeting.
Grooved stone maul.
Stone with two inverted cone-shaped pits.

CLEAR CREEK AND STEUBEN SITES

FOURTH ROW:
Pipe from Clear Lake site.
Pottery artifact, sectioned into six sections by rows of punctates, from Clear Lake.
Chert ball, with many little planes on surface, Steuben Site.

Hopewell Mound, was given to Thorne Deuel, Director of the Illinois State Museum, for a study of Hopewellian remains.

Collections from the Rench Village site include pottery rims, body sherds, and pots; shell artifacts and refuse; stone items; chert artifacts and scraps; bone artifacts, refuse, and burials; copper bead or bangle; carbonized corn, corn cob, and acorn; charcoal and mica.

Pottery

All pottery is Woodland, Hopewellian, and cord-decorated, with the exception of one Mississippian rim and two sherds. Like the Steuben pottery, it is simpler than that from Clear Lake, lacking richness of variation in decoration. The fine Hopewell is poorly represented, and the cord-decorated is present in only small amounts. Cord-decorated and Mississippian sherds were collected only from the plowed surface; the other types were found both on the surface and in the excavations. Pottery fragments included 313 rims, hundreds of body sherds, and portions of nine pots, two of which have been projected.

Dentate stamped[1] is the dominant type, mostly of simple decoration. Punctate ware, dominant at Steuben, ranks second at Rench Village. Ware showing the cord-wrapped paddle-edge stamps, abundant at Clear Lake, is scarce here as at the Steuben site. The proportion of Woodland cord-roughened undecorated pottery is larger at Rench Village than at Clear Lake. The boss, found frequently at Clear Lake, is infrequent here as at Steuben site. The cord-decorated ware lacks certain distinguishing characteristics of the Clear Lake pottery and seems closer to that of the Knoche Village, an almost pure Maples Mills site.

The dentate-stamped pottery collected includes 106 upper rims and 50 lower rims. Most designs are the simple repeated stamp. The rocked dentate stamp and the snowshoe appear once each. Six rims are odds. The crescent stamp is found in three upper rims and one lower rim.

The punctated ware, consisting of 91 upper rims and two lower rims, has mostly the simple two and three punctates, applied unevenly on both cord-roughened and smoothed surfaces. Single punctates decorate the outer edge of the lip on 35 of the rims. Several rims are odds.

Woodland cord-roughened pottery, with the cord-roughening extending to the lip, is represented by 36 rims, all of which are undecorated except two that have bosses. Plain smooth rims, undecorated, number 33; two of them are sand-tempered, similar to a Clear Lake ware.

Bar-stamped pottery is represented by two upper rims that show a plain bar stamp on a smooth surface.

Incised pottery included 11 upper rims, six lower rims and other sherds. Three upper rims, two lower rims, and two body sherds are similar to Cole and Deuel's No. 1 type or Black Sands incised, in which the incising was over cord-roughening, with boss and punctates. Two upper rims and four lower rims were similar to Griffin's Morton incised type of ware. Six upper rims and 21 sherds are unclassified.

The cord-wrapped-stick stamp (Cole and Deuel's term) appears on only eight rims, three of thin ware and five of heavy ware. This stamp is such as could be made by the edge of a cord-wrapped-paddle and is termed by the writer the corded-paddle-edge stamp.

Some 28 body sherds show designs on alternate areas or in zones, such as are described for Cole and Deuel's No. 2 type pottery or Griffin's Havana zoned.

[1] Designated by Cole and Deuel, in "Rediscovering Illinois," as type No. 2, and by James B. Griffin, Curator of the Ceramic Repository, University of Michigan, as Naples Dentate-Stamped.

Representatives of the finer Hopewell pottery and imitations included 14 rims and 11 body sherds. Hopewell channeled rims show horizontal incising or "brushing" and rocked incising. Imitations are of Hopewell cross-hatched incised and the rocked stamp, such as can be made with the raw edge of a broken clam shell. One limestone-tempered polished thin body sherd has incised and "brushed" zoned areas. One rim is smooth, polished, and incurved, similar to Markville Plain.

Pot portions, sufficient to project the whole form, are mostly undecorated cord-roughened, both plain and punctate, but including two that are different. One is a ware not previously reported in Illinois, so far as the writer knows. The fragments show a channeled bossed rim bearing horizontal "brushed" markings and a body on which the same markings were applied vertically to a smooth surface. The marks are parallel grooves, long, straight, narrow, and shallow, such as might be made by a three- or four-tined fork with closely spaced sharp-cornered flat tines about 1/16 inch wide. The lip is rounded; diameter of mouth was 12 inches. The pottery is about ¼ inch thick and seems similar to Cole and Deuel's No. 2 or Woodland Plain ware in paste, tempering, etc. Two similar sherds were found at Clear Lake.

The second was a roughly made, seemingly barrel-shaped pot. It had two irregular rows of punctates on the rim and zigzag incisings on the body.

There were four cord-decorated rims, all with decoration on the inner side of the lip but only one with it on the outer rim. Tempering material includes a little of the black sharp-angled hornblende; most is other grit. One rim bears the ear or node but not on a raised point.

The Mississippian ware comprises one rim and two sherds. The rim is red-painted, smooth, curved such as that of a low bowl, and has a hole in it, made when the bowl was made and painted red, an unusual feature. One sherd is smooth and rather thick, the thinner sherd has been leached of its tempering.

The Rench Village pottery complex, as known to date, seems closer to that of the Steuben site than to the Clear Lake. Factors considered are the simplicity of the dentate stamp design with its lack of variation or elaboration; the importance of the punctate ware; and the scarcity of the corded-paddle-edge decoration and of the boss.

Shell Items

Shell items include a number of large clam shell hoes, shell spoons, clam shells packed with soil containing many fish scales, many refuse clam shells, and a large number of snail shells.

The hoes have a ¾-inch round hole in the center, and a portion of the hinge has been smoothed off at the top. Bottoms are often worn down. These have been found at Clear Lake, Steuben, and the Sister Creek Whitnah Hopewellian village also, as well as at Mississippian villages. Spoons were made from another species of shell, thin and smooth. Hinges were removed or smoothed down, and the dark surface on the back was partially removed. One spoon has a finely scalloped edge.

The clam shells packed with soil and fish scales are thought to have been used to scrape scales from fish. Similar ones were also found at Clear Lake. The refuse clam shells were found all over the village. Snail shells, all of the same species, were found in lots of 20 to 50 at a number of places in the excavations.

Copper

The only copper found was a cone-shaped bead or bangle of rolled sheet copper. A string of copper and shell beads was reported found about 1922 on the Charles Gauwitz farm across the road, probably a part of the Rench Village site.

Stone Items

Pitted stones, showing shallow rough peckings in the center on one or both sides, are numerous. A few stones have cone-shaped holes with smooth walls. Holes are about ½ inch deep.

There were 30 celts, counting both whole and broken portions. Axes are represented by one blade, broken off at the groove. There are two grooved mauls, round or oval granite boulders encircled by grooves about an inch wide.

There are the usual ball-shaped pecking stones, which are found at almost all villages; but the gouge, flat on one side and convex on the other, is rather rare. Several sandstone sharpening stones were found, their straight grooves worn shallow or deep.

There was one whole pendant and eight portions. One unfinished pendant has two borings from opposite sides, in the usual way, but they do not meet; edges and surfaces are only partly smoothed. Clear Lake excavations have yielded fewer pendants than Rench Village, but the Steuben site is represented in the Schoenbeck collection by 16 portions.

A rare item is half of a polished stone ball, 1¼ inches in diameter. The broken surface is also somewhat polished, particularly on the higher areas, as though from handling or smoothing. Another unusual item is a small oblong stone, two inches long, one side of which is flat and the other ridged, and which has a flat polished tip. Its name and use are unknown. There were also several roughly shaped flat blades, ¼ inch thick, shaped around three edges and broken on the other. The only pipe found is half of a highly polished bowl.

Chert

Chert items included points, scrapers, flake knives, drills, and a bird effigy. Points are abundant, as they are at Steuben. Types of points include Woodland, Hopewell, Red Ocher, Maples Mills, and Mississippian. The smallest is ¾ inches long, the largest is 3⅛ inches, but the average is 1½ to 2 inches long. The bird effigy is of white chert and is similar to two found at the Steuben site (one by the Schoenbecks and one by Elliott). Drills are winged. There are three types of scrapers, and chert scraps are plentiful.

Bone

Bone items, aside from burials, include several broken beamers; a few awls, both single and double pointed; and a quantity of animal bones—deer, elk, beaver, dog, fish,

and turtle. There were portions of large and small antlers, some of which had been cut. Two antler tips had been shaped to a point.

Vegetables Remains

Carbonized corn kernels were excavated in two places; some of them had small remnants of cob attached. Charcoal and a carbonized acorn were also found.

Mica

Material excavated included a two-inch fragment of mica.

Unidentified

A fragment of material ¼ inch thick and about three by five inches in size, badly deteriorated, somewhat resembles old leather or hide. It has not been identified.

Clear Lake Site

An unusual item from Clear Lake Village is a pottery disk, 5/16 inch thick and 1 3/16 inch in diameter, which has a punctate design on each side. Lines of circular punctates mark one surface into six sections, as a pie is cut; a line of punctates outlines the circumference of the other face. The side wall is smooth but the two faces are rough.

Another recently collected item is an incomplete or broken disk pipe bowl, 2 3/16 inches in diameter with a ½-inch stem hole centered in the disk. This brings the total number of Clear Lake pipes to seven, which represent at least five types.

The "Brushed" ware that is reported in this paper for the Rench Village site is also here reported for the Clear Lake site. Several grit-tempered sherds were identified some years ago by Griffin, but have been overlooked in the list of types reported.

Sherds of small-sized buff-colored sand-tempered pottery with thinned and rounded lips are reported for the Clear Lake site. The surface is plain; decoration includes an irregular gashing or incising, a low horizontal "welting," and notches, but most of the sherds are undecorated.

Steuben Site

For the Steuben site there is reported a marble-like object, 11/16 inch in diameter, that appears to be of white chert. The surface consists of many small planes. It was found on the plowed surface.

BOTANY

INITIAL REPORT ON THE VASCULAR PLANTS OF SOUTHERN ILLINOIS

WILLIAM M. BAILEY
Southern Illinois University, Carbondale

The part of the state commonly designated as Southern Illinois consists of the eleven southernmost counties, namely Jackson, Williamson, Saline, Gallatin, Union, Johnson, Pope, Hardin, Alexander, Pulaski, and Massac. The area has 3,751 square miles. Two great rivers form its boundaries, the Ohio on the south and east, and the Mississippi on the west. The Ozark Hills extend east and west across the central part of the region. This name is applied because the range of hills was formed by the same general unlift that produced the Ozark Mountains in Missouri. The Ozark Hills were formed from an escarpment at the southern edge of the Pennsylvanian rocks. These hills and their slopes are very much dissected by erosion.

Immediately north of the Ozark Hills is the plain which is the oldest glaciated area in Illinois. South of the Ozark Hills is a low, flat plain, which is in the Mississippi embayment of the coastal plain of the Gulf of Mexico. Much of the vegetation of this plain is decidedly southern.

To the areas described above may be added the Mississippi River, Ohio River, and Wabash River borders.

The altitude of much of the plains north and south of the Ozark Hills is less than 400 feet above sea-level; that of the Ozark Hills is generally between 600 and 800 feet. The two highest points are William's Hill, in Pope County, with an altitude of 1065 feet, and Bald Knob, in Union County, with an altitude a little less than that of William's Hill.

The plain north of the Ozark Hills and the northern slopes of these hills are drained by two rivers, the Big Muddy River which flows southwestward into the Mississippi River and the Saline River which flows southeastward into the Ohio River. The plain south of the Ozark Hills and the southern slopes of the hills are also drained by two rivers, the Cache River and the Big Bay, both of which occupy an old channel of the Ohio River. The Cache River flows southwestward, and discharges its water into the Ohio a short distance above the junction of the latter with the Mississippi. The Big Bay flows southeastward into the Ohio.

The soils of the greater part of Southern Illinois are not of very good quality. The fine texture and impervious subsoil of the upland soils prevent good drainage and aeration. During the winters the soil is unfrozen much of the time. There is much erosion and leaching by the winter as well as the summer and spring rains. The rapid leaching has resulted in soil acidity and in deficiency of mineral nutrients for plants.

Climate is the greatest factor in the development of soils and of vegetation. Southern Illinois extends from 37 degrees to 38 degrees north latitude. The summers are hot, averaging about 80 degrees F. for July. The temperature for January averages near the freezing point. The growing season has an average length of 190 days in the north part of the region to 210 days in the south part. The average annual rainfall of Southern Illinois ranges from 35 inches to 50 inches in different parts of the area. The highest rainfall of 45 to 50 inches occurs on the south slopes of the Ozark Hills. This higher rainfall is probably caused by the cooling of the warm, damp winds from the south as they ascend these slopes. The vegetation in this area is more mesic than in other parts of the region.

The heaviest rainfall is usually in the spring and early summer. In the later part of the summer the low pressure areas are sometimes so far north that the hot, dry subtropical winds blow across the region.

The principal type of vegetation in Southern Illinois consists of the hardwood forests. On the hills and uplands the oaks and hickories are the dominant species, associated with elms, maples, ash, sycamore, wild black cherry, and other species. On the flood-plains of the streams are found mixed hardwood forests.

Clearing the land for agricultural purposes, cutting the timber for commercial and domestic uses, and destructive fires have resulted in the destruction of most of the virgin timber. The Shawnee National Forest in Southern Illinois has been established by the purchase of forest land and submarginal land by the United States Government, in order to protect the forests from destruction and preserve them for future use, to protect the land with steep slopes from destructive erosion, and to alleviate destructive floods. Already the forestry station at Jonesboro is more than paying expenses by the sale of timber.

Only isolated, comparatively small areas of prairie vegetation occurred in Southern Illinois. A few small remnants of this prairie vegetation may still be found.

In Southern Illinois there are numerous species of plants that are limited to the southern part of the state, so far as Illinois is concerned. Among these are the following: the Short-leaf Yellow Pine *(Pinus echinata)*, on the bluffs just east of Wolf Lake, in the northwest part of Union County; the Pink Azalea *(Rhododendron roseum)* in the same locality; the Winged Elm *(Ulmus alata)*, the Cucumber Tree *(Magnolia acuminata)*, the Tulip Tree *(Liriodendron tulipifera)*, the Chestnut Oak *(Quercus montana)* on the higher elevations of some of the hills of Atwood Ridge, in Union County; the Bald Cypress *(Taxodium distichum)*, Water Elm *(Planera aquatica)*, Tupelo Gum *(Nyssa aquatica)*, Water Locust *(Gleditsia aquatica)*, and Virginia Willow *(Itea virginica)*, in the swamps and low woods of the plain south of the Ozark Hills; the Willow Oak *(Quercus phellos)* in Massac County; the Overcup Oak *(Quercus lyrata)*, in the south third of Illinois, in swamps and bottomland woods; Schneck's Oak *(Quercus shumardii)*, in damp woods near streams; Mississippi Hackberry *(Celtis laevigata)*, in the southern third of Illinois, on bottom lands of

large rivers; *Catalpa speciosa*, on bottom lands of the Ohio and Wabash Rivers; Sweet Gum Tree *(Liquidambar styraciflua)*, in swampy woods; Red Buckeye *(Aesculus discolor)*, in Union County State Forest and the Forest at Horseshoe Lake, in Alexander County; Farkleberry *(Vaccinium arboreum)*, Southern Buckthorn *(Bumelia lycioides)*, Mistletoe *(Phoradendron flavescens)*, parasitic on elms and other bottomland trees; Gray Polypody *(Polypodium polypodioides)*, a fern growing on rocks and trees in Jackson County and southward; Filmy Fern *(Trichomanes boschianum)*, found in Jackson Hollow, Pope County; *Sedum pulchellum*, on sandstone rocks; Southern Cane *(Arundinaria gigantea)*, on stream banks and in swamp places; wisteria *(Wisteria macrostachya)*, and cross-vine *(Bignonia capreolata)*, near the Ohio River.

In our explorations for vascular plants in Southern Illinois, we have collected more than 600 species. We are planning to continue this work.

REFERENCES

Britton, Nathaniel Lord and Hon. Addison Brown. 1913—Illustrated flora of the Northern United States, Canada and the British Possessions. Second Edition. The New York Botanical Garden. 3 volumes.

Fassett, Norman C. 1940—A manual of aquatic plants. McGraw-Hill Book Co., Inc. 382 pp.

Gray's New Manual of Botany. Seventh edition. 1908—American Book Co. 926 pp.

Hall, Edward Emerson. 1940—The geography of the interior low plateau and associated lowlands of southern Illinois. 109 pp.

Jones, George Neville. 1945—Flora of Illinois. Monograph No. 2, Am. Midl. Nat., Notre Dame, Ind. 317 pp.

Miller, R. B. and L. R. Tehon. 1926—The native and naturalized trees of Illinois. Nat. History Survey Bull. 18. 339 pp.

Sargent, Charles Sprague. 1933—Manual of the trees of North America. Houghton Mifflin Co. 910 pp.

List of Species Collected

Equisetaceae
- Equisetum arvense L.

Ophioglossaceae
- Botrychium virginianum (L.) Sw.

Polypodiaceae
- Adiantum pedatum L.
- Asplenium platyneuron (L.) Oakes
- Asplenium trichomanes L.
- Athyrium angustum (Willd.) Presl.
- Camptosorus rhizophyllus (L.) Link
- Cheilanthes lanosa (Michx.) D.C. Eaton
- Cystopteris fragilis (L.) Bernh.
- Diplazium pycnocarpon (Spreng.) Broun
- Dryopteris marginalis (L.) Gray
- Onoclea sensibilis L.
- Pellaea atropurpurea (L.) Link
- Phegopteris hexagonoptera (Michx.) Fee
- Polypodium polypodioides (L.) Watt
- Polypodium virginianum L.
- Polystichum acrostichoides (Michx.) Schott.
- Pteridium latiusculum (Desv.) Hieron.
- Woodsia obtusa (Spreng.) Torr.

Pinaceae
- Pinus echinata Mill.

Taxodiaceae
- Taxodium distichum (L.) Rich.

Cupressaceae
- Juniperus virginiana L.

Typhaceae
- Typha angustifolia L.
- Typha latifolia L.

Sparganiaceae
- Sparganium eurycarpum Engelm.

Alismaceae
- Alisma subcordatum Raf.
- Echinodorus radicans (Nutt.) Engelm.
- Sagittaria graminea Michx.
- Sagittaria latifolia Willd.

Hydrocharitaceae
- Limnobium spongia (Bosc) Steud.

Gramineae
- Arundinaria gigantea (Walt.) Chapm.
- Bromus tectorium L.
- Poa pratensis L.
- Eragrostis pectinacea (Michx.) Nees
- Eragrostis poaeoides (L.) Beauv.
- Uniola latifolia Michx.
- Triodia flava (L.) Smyth.
- Elymus virginicus L.
- Hystrix patula Moench.
- Eleusine indica (L.) Gaertn.
- Digitaria sanguinalis (L.) Scop.
- Paspalum circulare Nash

Paspalum fluitans (Ell.) Kunth
Panicum anceps Michx.
Panicum polyanthes Schult.
Echinochloa crusgalli (L.) Beauv.
Setaria lutescens (Weigel) F. T. Hubb.
Cenchrus longispinus (Hack.) Fern.
Andropogon virginicus L.
Erianthus alopecuroides (L.) Ell.
Erianthus contortus Ell.
Sorghum halepense (L.) Pers.

Cyperaceae
Cyperus ovularis (Michx.) Torr.
Cyperus ferruginescens Boeckl.
Eleocharis obtusa (Willd.) Schult.
Scirpus lineatus Michx.
Carex vulpinoidea Michx.
Carex projecta Mack.
Carex grayii Carey
Carex frankii Kunth
Carex lupuliformis Sartw.
Carex squarrosa L.
Carex lurida Wahl.

Araceae
Arisaema atrorubens (Ait.) Blume
Arisaema dracontium (L.) Schott
Peltandra virginica (L.) Kunth
Acorus calamus L.

Commelinaceae
Tradescantia canaliculata Raf.
Tradescantia virginiana L.
Commelina communis L.

Juncaceae
Juncus effusus L.
Juncus macer S.F. Gray
Juncus marginatus Rostk.
Juncus torreyi Coville
Juncus acuminatus Michx.
Luzula multiflora (Ehrh.) Lej.

Liliaceae
Allium canadense L.
Allium stellatum Ker
Nothoscordum bivalve (L.) Britt.
Hemerocallis fulva L.
Erythronium americanum Ker
Erythronium albidum Nutt.
Camassia scillioides (Raf.) Cory
Ornithogallum umbellatum L.
Asparagus officinalis L.
Smilacina racemosa (L.) Desf.
Uvularia grandiflora Sm.
Polygonatum biflorum (Walt.) Ell.
Stenanthium gramineum (Ker) Morong.
Trillium sessile L.
Trillium recurvatum Beck
Trillium grandiflorum (Mich.) Salisb.
Smilax hispida Muhl.
Smilax pulverulenta Michx.

Amaryllidaceae
Agave virginica L.
Hypoxis hirsuta (L.) Coville

Iridaceae
Iris shrevei Small
Iris fulva Ker
Iris cristata Ait.
Sisyrinchium albidum Raf.

Orchidaceae
Cypripedium parviflorum Salisb.
Orchis spectabilis L.
Habenaria peramoena Gray
Calapogon pulchellus (Salisb.) R. Br.
Liparis liliifolia (L.) Rich.
Aplectrum hyemale (Muhl.) Torr.
Corallorrhiza wisteriana Conrad

Saururaceae
Saururus cernuus L.

Salicaceae
Populus heterophylla L.
Populus deltoides Marsh.
Salix nigra Marsh.
Salix cordata Muhl.
Salix humilis Marsh.

Juglandaceae
Juglans cinerea L.
Juglans nigra L.
Carya illinoensis (Wang.) K. Koch
Carya cordiformis (Wang.) K. Koch
Carya tomentosa Nutt.
Carya ovata (Mill.) K. Koch

Betulaceae
Betula nigra L.
Alnus rugosa (Duroi) Spreng.
Corylus americana Walt.
Carpinus caroliniana Walt.
Ostrya virginiana (Mill.) K. Koch

Fagaceae
Fagus grandifolia Ehrh.
Quercus imbricaria Michx.
Quercus phellos L.
Quercus marilandica Muench.
Quercus rubra L.
Quercus rubra, var. pagodaefolia Ashe
Quercus borealis Michx. f.
Quercus palustris Muench.
Quercus shumardii Buckl.
Quercus velutina Lam.
Quercus alba L.
Quercus stellata Wang.
Quercus macrocarpa Michx.
Quercus lyrata Walt.
Quercus muhlenbergii Engelm.
Quercus prinus L.
Quercus montana Willd.
Quercus bicolor Willd.

Ulmaceae
Ulmus americana L.
Ulmus alata Michx.
Ulmus fulva Michx.
Planera aquatica (Walt.) J.F. Gmel.
Celtis occidentalis L.
Celtis laevigata Willd.

Urticaceae
Urtica chamaedryoides Pursh
Boehmeria cylindrica (L.) Sw.
Pilea pumila (L.) Gray
Laportea canadensis (L.) Gaud.

Santalaceae
Comandra umbellata (L.) Nutt.

Loranthaceae
Phoradendron flavescens (Pursh) Nutt

Aristolochiaceae
Aristolochia tomentosa Sims
Asarum reflexum Bickn.

Polygonaceae
Rumex acetosella L.
Rumex altissimus Wood
Rumex verticillatus L.
Rumex crispus L.
Rumex obtusifolius L.
Rumex fueginus Phil.
Polygonum aviculare L.
Polygonum pennsylvanicum L.
Polygonum lapathifolium L.
Polygonum hydropiperoides Michx.
Polygonum periscaria L.
Polygonum virginianum L.
Polygonum sagittatum L.
Polygonum scandens L.
Brunnichia cirrhosa Gaertn.

Chenopodiaceae
Chenopodium album L.
Chenopodium ambrosioides L.
Chenopodium hybridum L.

Amaranthaceae
Amaranthus spinosus L.
Amaranthus retroflexus L.
Amaranthus blitoides Wats.
Froelichia campestris Small

Phytolaccaceae
Phytolacca americana L.

Nyctaginaceae
Mirabilis nyctaginea (Michx.) MacM.

Portulacaceae
Claytonia virginica L.
Portulaca oleracea L.

Caryophyllaceae
Cerastium nutans Raf.
Stellaria media (L.) Cyrill.
Stellaria longifolia Muhl.
Silene antirrhina L.
Silene stellata (L.) Ait.
Saponaria officinalis L.

Magnoliaceae
Magnolia acuminata L.
Liriodendron tulipifera L.

Annonaceae
Asimina triloba (L.) Dunal.

Ranunculaceae
Isopyrum biternatum (Raf.) T. & G.
Aquilegia canadensis L.
Actaea alba (L.) Mill.
Delphinium tricorne Michx.
Myosurus minimus L.
Ranunculus flabellaris Raf.
Ranunculus oblongifolius Ell.
Ranunculus abortivus L.
Ranunculus micranthus Nutt.
Ranunculus pusillus Poir.
Ranunculus septentrionalis Poir.
Ranunculus fascicularis Muhl.
Ranunculus hispidus Michx.
Ranunculus parvulus L.
Thalictrum revolutum DC.
Anemone virginiana L.
Anemonella thalictroides (L.) Spach.
Hepatica acutiloba DC.
Clematis pitcheri T. & G.

Nelumbonaceae
Nelumbo lutea (Willd.) Pers.

Nymphaeaceae
Nuphar advena Ait.

Ceratophyllaceae
Ceratophyllum demersum L.

Berberidaceae
Podophyllum peltatum L.
Caulophyllum thalictroides (L.) Michx.

Menispermaceae
Cocculus carolinus (L.) DC.

Lauraceae
Sassafras albidum (Nutt.) Nees
Lindera benzoin (L.) Blume

Papaveraceae
Sanguinaria canadensis L.
Stylophorum diphyllum (Michx.) Nutt

Fumariaceae
Dicentra cucullaria (L.) Bernh.
Corydalis flavula (Raf.) DC.

Cruciferae
Brassica arvensis (L.) Rabenh.
Barbarea vulgaris R. Br.
Rorippa palustris (L.) Besser
Sisymbrium officinale (L.) Scop.
Sisymbrium altissimum L.
Descurainia brachycarpa (Richards) O.E. Schulz
Draba brachycarpa Nutt.
Draba verna L.
Dentaria laciniata Muhl.
Cardamine bulbosa (Schreb.) BSP.
Cardamine pennsylvanica Muhl.
Cardamine arenicola Britt.
Arabis virginica (L.) Poir.
Arabis laevigata (Muhl.) Poir.
Arabidopsis thaliana (L.) Heynh.
Nasturtium officinale R. Br.
Neobeckia aquatica (Eaton) Greene
Lepidium virginicum L.
Thlaspi arvense L.
Capsella bursa-pastoris (L.) Medic.

Capparidaceae
Polanisia graveolens Raf.

Crassulaceae
Sedum pulchellum Michx.
Sedum ternatum Michx.
Sedum telephioides Michx.
Penthorum sedoides L.

Saxifragaceae
Heuchera parviflora Bartl.
Heuchera hirsuticaulis (Wheelock) Rydb.
Saxifraga virginiensis Michx.

Hydrangeaceae
Hydrangea arborescens L.

Grossulariaceae
Ribes cynosbati L.

Hamamelidaceae
Liquidambar styraciflua L.

Platanaceae
Platanus occidentalis L.

Rosaceae
Gillenia stipulata (Muhl.) Trel.
Potentilla recta L.
Potentilla monspeliensis L.
Potentilla simplex Michx.
Geum canadense Jacq.
Agrimonia rostellata Wallr.
Rubus occidentalis L.
Rubus allegheniensis Porter
Rubus argutus Link
Rubus flagellaris Willd.
Amelanchier arborea (Michx. f.) Fern.
Malus ioensis (Wood) Britt.
Prunus americana Marsh.
Prunus hortulana Bailey
Prunus serotina Ehrh.
Rosa setigera Michx.
Rosa carolina L.

Leguminosae
Desmanthus illinoensis Michx. MacM.
Cercis canadensis L.
Gymnocladus dioica (L.) K. Koch
Gleditsia triacanthos L.
Gleditsia aquatica Marsh.
Cassia marilandica L.
Cassia nictitans L.
Baptisia leucantha T. & G.
Crotalaria sagittalis L.
Trifolium reflexum L.
Trifolium repens L.
Trifolium hybridum L.
Trifolium pratense L.
Trifolium procumbens L.
Melilotus officinalis (L.) Lam.
Melilotus alba Desr.
Tephrosia virginiana (L.) Pers.
Robinia pseudo-acacia L
Desmodium pauciflorum (Nutt.) DC.
Desmodium glutinosum (Muhl.) Wood
Desmodium nudiflorum (L.) DC.
Desmodium illinoense Gray
Desmodium dillenii Darl.
Desmodium marilandicum (L.) DC.
Desmodium ciliare DC.
Desmodium canadense (L.) DC.
Lespedeza repens (L.) Bart.
Lespedeza procumbens Michx.
Lespedeza violacea (L.) Pers.
Lespedeza virginica (L.) Britt.
Lespedeza striata (Thunb.) H. & A.
Stylosanthes biflora (L.) BSP.
Apios americana Medic.
Phaseolus polystachys (L.) BSP.
Strophostyles helvola (L.) Britt.
Strophostyles leiosperma (T. & G.) Piper
Clitoria mariana L.
Amphicarpa comosa (L.) G. Don
Galactia mississippiensis (Vail) Rydb.

Geraniaceae
Geranium maculatum L.
Geranium carolinianum L.

Oxalidaceae
Oxalis violacea L.
Oxalis stricta L.
Oxalis cymosa Small

Linaceae
Linum medium (Planch.) Britt.

Balsaminaceae
Impatiens biflora Walt.
Impatiens pallida Nutt.

Polygalaceae
Polygala sanguinea L.

Euphorbiaceae
Croton capitatus Michx.
Acalypha gracilens Gray
Chamaesyce maculata (L.) Small
Chamaesyce supina (Raf.) Moldenke
Euphorbia corollata L.
Euphorbia marginata Pursh
Poinsettia dentata (Michx.) Small

Celastraceae
Celastrus scandens L.
Euonymus atropurpureus Jacq.

Aquifoliaceae
Ilex decidua Walt.

Anacardiaceae
Rhus copallina L.
Rhus glabra L.
Rhus radicans L.
Rhus aromatica Ait.

Staphyleaceae
Staphylea trifolia L.

Aceraceae
Acer saccharinum L.
Acer rubrum L.
Acer saccharum Marsh.
Acer nigrum Michx. f.
Acer negundo L.

Aesculaceae
Aesculus glabra Willd.
Aesculus discolor Pursh

Rhamnaceae
Ceanothus americanus L.

Vitaceae
Vitis aestivalis Michx.
Ampelopsis arborea (L.) Koehne
Parthenocissus quinquefolia (L.) Planch.

Tiliaceae
Tilia americana L.

Malvaceae
Sida spinosa L.
Hibiscus militaris Cav.
Hibiscus lasiocarpos Cav.

Hypericaceae
Hypericum punctatum Lam.
Ascyrum multicaule Michx.
Triadenum virginicum (L.) Raf.

Violaceae
Hybanthus concolor (Forst.) Spreng.
Viola pedata L.
Viola falcata Greene
Viola papilionacea Pursh
Viola missouriensis Greene
Viola sororia Willd.
Viola eriocarpa Schw.
Viola striata Ait.
Viola rafinesquii Greene
Viola viarum Pollard

Passifloraceae
Passiflora lutea L.

Lythraceae
Rotala ramosior (L.) Koehne
Decodon verticillatus (L.) Ell.
Lythrum alatum Pursh
Cuphea petiolata (L.) Koehne

Onagraceae
Jussiaea diffusa Forsk.
Ludwigia alternifolia L.
Oenothera biennis L.
Oenothera laciniata Hill
Oenothera pilosella Raf.
Oenothera speciosa Nutt.
Oenothera linifolia Nutt.
Circeaea latifolia Hill

Cornaceae
Cornus racemosa Lam.
Cornus florida L.
Nyssa sylvatica Marsh.
Nyssa aquatica L.

Araliaceae
Aralia spinosa L.
Aralia racemosa L.

Umbelliferae
Eryngium yuccifolium Michx.
Daucus carota L.
Torilis japonicus (Houtt.) DC.
Sanicula marilandica L.
Sanicula canadensis L.
Osmorhiza longistylis (Torr.) DC.
Cryptotaenia canadensis (L.) DC.
Erigenia bulbosa (Michx.) Nutt
Chaerophyllum procumbens (L.) Crantz
Conium maculatum L.
Sium cicutaefolium Gmel.
Cicuta maculata L.
Thaspium sylvaticum (Benke) n. comb.
Polytaenia nuttallii DC.

Ericaceae
Monotropa uniflora L.
Rhododendron roseum (Loisel.) Rehd.
Vaccinium vacillans Kalm

Primulaceae
Lysimachia nummularia L.
Lysimachia ciliata L.
Lysimachia lanceolata Walt.
Dodecatheon meadia L.
Dodecatheon frenchii (Vasey) Rydb.

Ebenaceae
Diospyros virginiana L.

Styracaceae
Styrax americana Lam.

Oleaceae
Fraxinus americana L.
Fraxinus lanceolata Borkh.
Forestiera acuminata Poir.

Loganiaceae
Spigelia marylandica L.

Gentianaceae
Sabatia angularis (L.) Pursh
Obolaria virginica L.

Apocynaceae
Amsonia tabernaemontana Walt.
Apocynum cannabinum L.

Asclepiadaceae
Asclepias tuberosa L.
Asclepias syriaca L.
Asclepias purpurascens L.
Asclepias incarnata L.
Asclepias perennis Walt.
Acerates hirtella Pennell
Ampelamus albidus (Nutt.) Britt.
Asclepiodora viridis (Walt.) Gray

Convolvulaceae
Convolvulus americanus (Sims) Greene
Convolvulus arvensis L.
Ipomoea pandurata (L.) G.F.W. Mey.
Ipomoea lacunosa L.
Ipomoea purpurea (L.) Roth
Ipomoea hederacea Jacq.
Cuscuta pentagona Engelm.
Cuscuta polygonorum Engelm.

Polemoniaceae
Phlox paniculata L.
Phlox glaberrima L.
Phlox pilosa L.
Phlox divaricata L.
Phlox bifida Beck
Polemonium reptans L.

Hydrophyllaceae
Hydrophyllum appendiculatum Michx.
Phacelia bipinnatifida Michx.
Phacelia purshii Buckl.
Hydrolea affinis Gray

Boraginaceae
Heliotropium indicum L.
Mertensia virginica (L.) Link
Myosotis verna Nutt.
Lithospermum canescens (Michx.) Lehm.
Lithospermum arvense L.

Verbenaceae
Verbena bracteata Lag. & Rodr.
Verbena urticaefolia L.

Verbena stricta Vent.
Verbena hastata L.
Verbena simplex Lehm.
Phyla lanceolata (Michx.) Greene

Labiatae
Teucrium canadense L.
Scutellaria lateriflora L.
Scutellaria ovata Hill
Scutellaria ovalifolia Michx.
Scutellaria incana Spreng.
Scutellaria nervosa Pursh
Marrubium vulgare L.
Agastache nepetoides (L.) Ktze.
Nepeta cataria L.
Physostegia virginiana (L.) Benth.
Prunella vulgaris L.
Leonurus cardiaca L.
Stachys tenuifolia Willd.
Blephilia hirsuta (Pursh) Torr.
Monarda bradburiana Beck
Monarda fistulosa L.
Hedeoma pulegioides (L.) Pers.
Pycnanthemum pycnanthemoides (Leavenw.) Fern.
Pycnanthemum flexuosum (Walt.) BSP.
Cunila origanoides (L.) Britt.
Lycopus rubellus Moench.
Lycopus americanus Muhl.
Perilla frutescens (L.) Britt.

Solanaceae
Physalis pubescens L.
Datura stramonium L.
Solanum carolinense L.
Solanum rostratum Dunal
Solanum nigrum L.

Scrophulariaceae
Verbascum thapsus L.
Chelone obliqua L.
Pentstemon hirsutus (L.) Willd.
Pentstemon pallidus Small
Pentstemon digitalis Nutt.
Pentstemon tubaeflorus Nutt.
Collinsia verna Nutt.
Linaria vulgaris Mill.
Lindernia dubia (L.) Pennell
Gratiola virginiana L.
Mimulus alatus Soland.
Bacopa rotundifolia (Michx.) Wettst.
Veronicastrum virginicum (L.) Farw.
Veronica peregrina L.
Veronica arvensis L.
Aureolaria flava (L.) Farw.
Gerardia paupercula Gray
Gerardia tenuifolia Vahl
Dasistoma macrophylla (Nutt.) Raf.
Pedicularis canadensis L.

Lentibulariaceae
Utricularia gibba L.

Orobanchaceae
Epifagus virginiana (L.) Bart.
Orobanche unifora L.

Bignoniaceae
Catalpa speciosa Warder
Bignonia capreolata L.
Campsis radicans (L.) Seem.

Acanthaceae
Ruellia ciliosa Pursh
Ruellia pedunculata Torr.

Phrymaceae
Phryma leptostachya L.

Plantaginaceae
Plantago rugelii Dcne.
Plantago lanceolata L.
Plantago aristata Michx.

Rubiaceae
Houstonia caerulea L.
Houstonia lanceloata (Poir) Britt.
Cephalanthus occidentalis L.
Diodia teres Walt.
Diodia virginiana L.
Spermacoce glabra Michx.
Galium aparine L.
Galium circaezans Michx.
Galium concinuum T. & G.
Galium obtusum Bigel.
Galium tinctorium L.

Caprifoliaceae
Sambucus canadensis L.
Symphoricarpos orbiculatus Moench.
Lonicera japonica Thunb.
Triosteum angustifolium L.

Valerianaceae
Valerianella radiata (L.) Dufr.

Cucurbitaceae
Sicyos angulatus L.

Campanulaceae
Campanula americana L.
Campanula intercedens Witasek
Specularia perfoliata (L.) A.DC.

Lobeliaceae
Lobelia cardinalis L.
Lobelia siphilitica L.
Lobelia inflata L.

Compositae
Iva ciliata Willd.
Ambrosia elatior L.
Ambrosia trifida L.
Ambrosia bidentata Michx.
Xanthium pennsylvanicum Wallr.
Vernonia altissima Nutt.
Vernonia missurica Raf.
Elephantopus carolinianus Willd.
Eupatorium purpureum L.
Eupatorium serotinum Michx.
Eupatorium rugosum Houtt.
Eupatorium coelestinum L.
Mikania scandens (L.) Willd.
Liatris squarrosa (L.) Willd.
Liatris bebbiana Rydb.
Chrysopsis villosa (Pursh) Nutt.
Solidago caesia L.

Solidago rugosa Mill.
Solidago nemoralis Ait.
Solidago drummondii T. & G.
Solidago altissima L.
Solidago speciosa Nutt.
Solidago speciosa rigidiuscula T. & G.
Solidago rigida L.
Boltonia asteroides (L.) L'Her.
Aster anomalus Engelm.
Aster shortii Lindl.
Aster cordifolius L.
Aster drummondii Lindl.
Aster sagittifolius Wedem.
Aster novae angliae L.
Aster turbinellus Lindl.
Aster ericoides L.
Aster salicifolius Lam.
Aster interior Wieg.
Aster lateriflorus (L.) Britt.
Aster patens Ait.
Erigeron pulchellus Michx.
Erigeron philadelphicus L.
Erigeron strigosus Muhl.
Erigeron annuus (L.) Pers.
Erigeron divaricatus Michx.
Erigeron canadensis L.
Pluchea camphorata (L.) DC.
Antennaria plantaginifolia Hook.
Gnaphalium obtusifolium L.
Silphium terebinthinaceum Jacq.
Silphium laciniatum L.
Silphium Silphium integrifolium Michx.
Silphium perfoliatum L.
Parthenium integrifolium L.
Heliopsis helianthoides (L.) Sweet
Eclipta alba (L.) Hassk.
Rudbeckia hirta L.
Rudbeckia subtomentosa Pursh
Galinsoga ciliata (Raf.) Blake
Helianthus strumosus L.
Helianthus tuberosus L.
Helianthus maximiliani Schrad.
Actinomeris alternifolia (L.) DC.
Verbesina helianthoides Michx.
Coreopsis pubescens L.
Coreopsis tripteris L.
Bidens comosa (Gray) Wieg.
Bidens aristosa (Michx.) Britt.
Helenium nudiflorum Nutt.
Helenium tenuifolium Nutt.
Achillea millefolium L.
Anthemis cotula L.
Chrysanthemum leucanthemum L.
Cacalia atriplicifolia L.
Senecio plattensis Nutt.
Senecio aureus L.
Senecio glabellus Poir.
Arctium minus (Hill) Bernh.
Cirsium vulgare (Savi) Airy-Shaw
Cirsium discolor (Muhl.) Spreng.
Cirsium altissimum (L.) Spreng.
Serinia oppositifolia (Raf.) Ktze.
Krigia dandelion (L.) Nutt.
Krigia biflora (Walt) Blake
Lactuca scariola L.
Lactuca canadensis L.
Lactuca floridana (L.) Gaertn.
Pyrrhopappus carolinianus (Walt.) DC.
Taraxacum vulgare (Lam.) Schrank

FERNS OF ROCK RIVER VALLEY IN ILLINOIS*

EGBERT W. FELL AND GEORGE B. FELL
Rockford, Illinois

The purpose of this paper is to give some account of the fern habitats and of the present fern population of the drainage basin of Rock River from the Wisconsin state line to Dixon, a distance of fifty miles. The area includes Boone, Winnebago, eastern Stephenson, western Ogle and a part of Lee Counties. This is a glaciated, partly wooded but mostly prairie area where the streams have cut hills, cliffs and ravines which with their bordering woods, the sandy area in northeastern Winnebago County and the sandstone area in Ogle County, provide the diversification of soil and terrain necessary for the formation of differing fern habitats. The woods are mostly an oak-hickory association. The rock outcrops are small and infrequent except along Kishwaukee and Rock Rivers. They are of Galena dolomite and Plattville limestone except in Ogle County where there is a considerable exposure of St. Peter sandstone along Rock River. In northern Boone County there are peaty bog areas, and in the sand area in Winnebago County there are boggy areas with Sphagnum and northern plants that are not found elsewhere in this region.

The fern habitats in the area are: sandstone outcrops and ravines, exposed and shaded; limestone outcrops and ravines, exposed and shaded; slough marshes and bog areas; bottomland woods and upland woods. The species growing typically on sandstone are *Woodsia obtusa, Woodsia ilvensis, Polypodium virginianum, Dryopteris disjuncta* and *Dryopteris phegopteris.* Those growing typically on limestone are *Cystopteris bulbifera, Camptosorus rhizophyllus, Cryptogramma stelleri* and *Pellaea glabella.* Typically inhabiting marshes and other wet places are *Osmunda regalis, Osmunda cinnamomea, Osmunda claytoniana, Onoclea sensibilis, Pteretis struthiopteris, Dryopteris thelypteris* and *Dryopteris cristata.* Typical of woods are *Botrychium dissectum, Botrychium obliquum, Botrychium multifidum, Botrychium virginianum, Cystopteris fragilis, Polystichum acrostichoides, Dryopteris hexagonoptera, Dryopteris marginalis, Dryopteris intermedia, Dryopteris spinulosa, Asplenium platyneuron, Athyrium angustum, Athyrium thelypterioides, Adiantum pedatum* and *Pteridium latiusculum.* This list of species known to grow in this area does not account for all the ferns found in Northern Illinois, because the unglaciated area in Jo Daviess County with its Fee fern and the Lake County bog with the Virginia chain fern are not included. Few of our species are common and there are only a few areas where ferns are abundant. Specimens of each species are deposited in the herbarium of the Illinois State Mu-

* The field work was done by the authors over the past five years with collaboration of George D. Fuller whose help is greatly appreciated.

seum. The nomenclature is that of Jones.[1]

Botrychium dissectum Spreng. The cut-leaved grape fern is known in only one station in this area. It grows in an upland black oak woods on the Winnebago-Boone County line where there is a colony of considerable size in close association with the next species. The plants of both species in this colony are all small, equally fertile, equally bronzed, and look much alike except for the leaf cutting. In *B. dissectum* the leaf segments are laciniate but there is some variation in this.

Botrychium obliquum Muhl. The oblique grape fern is generally distributed over this area but is found less frequently than the next species. It is most frequent in the sand area of northern Winnebago County and in the sandstone area in Ogle County. It is usually found as an individual but occasionally there are several plants in a small area. It is at times found in unusual situations, as an open pasture, a roadside, the middle of a parking space in a forest preserve. It is of thinner texture and the stem is more slender than in *B. multifidum*. The leaf segments are few and the serrations are acute.

Botrychium multifidum (S. G. Gmel.) Rupr. The leathery grape fern seems to be more frequent in this area than the preceding but is of the same distribution preferring the sandy areas. The ultimate leaf segments are crowded and are obtuse.

The above three species have much in common. They inhabit woods, starting to grow in late June. The blade is fully developed by September. The sporophyll ripens and withers quickly but the blade persists over winter, often staying green and fresh until after the second year's blade is well developed. We have had a number of grape ferns under observation for several years. Some of them are large, some small, and they seem to remain so although individual plants vary somewhat in size from year to year. The size of the plant has little to do with whether it has spores. There seems to be no difference as to size, bronzing, or other growth habits. They are practically identical except for the cutting of the leaf blades.

Botrychium virginianum (L.) S. M. The rattlesnake fern is generally distributed and is common over the area, growing especially on sandy hillsides in woods, shade being the primary requirement, moisture secondary. It starts to grow about April 20th in the average spring and is very sensitive to frost. There is a material difference in the size of plants, the small ones sporulating about as often as the large. In our area the difference in the fineness of leaf cutting is not marked enough to justify separation into varieties.

Osmunda regalis L. The royal fern grows in the sandy area of northern Winnebago County but we have not found it elsewhere in this area. Though usually found with the two other osmundas in typical situations it is not uncommon for the two others to be plentiful and this fern absent. It does not cover a large area anywhere. Growth starts in late March. It sporulates better in the sun. In the field the brown sporophylls are conspicuous

[1] Jones, G. N. "An Enumeration of Illinois Pteridophyta." Am. Mid. Nat., Vol 38, No. 1, pp. 76-126, July 1947.

but at a distance are easily mistaken for the fruiting panicles of Rumex.

Osmunda cinnamomea L. The cinnamon fern is found in the north Winnebago County sand area but is much more plentiful and grows more robustly in shaded ravines in the Ogle County sandstone area where it is associated with *O. claytoniana*. It is much less plentiful than the latter. It grows on the east face of Castle Rock in a dry exposed situation where it is plentiful but the plants are small. Growth begins the latter part of March though it is quite sensitive to frost. The sporophylls grow, ripen and disappear quickly before the leaves are fully grown; not all plants have spores every year.

Osmunda claytoniana L. The interrupted fern is our most common osmunda. It grows preferably in wet sandy situations but it is also found on the wooded bank of Kishwaukee River in a limestone region. Its moisture requirement is less than that of the other osmundas but it does not grow as robustly in dry places. Growth starts about April 1st in an average season.

Onoclea sensibilis L. The sensitive fern is found all over this area, and although a weed so far as looks and use are concerned it is nowhere common enough to be a nuisance. It prefers wet open places but is also found in woods that are not particularly wet. Growth starts about April 15th and being very sensitive to frost it often has to make several starts.

Pteretis struthiopteris (Michx.) Nieuw. The ostrich fern is quite uncommon here. In a ravine in the sandstone area in Ogle county are three colonies growing in the shade in a floodplain situation. It is not known to occur elsewhere in the area. It seems to sporulate better in the sun. It is readily found in winter by the stiffly erect sporophylls which form in late summer.

Cystopteris fragilis (L.) Bernh. The brittle fern is common over the area. It is usually found in moist woods but also on shaded limestone and to a lesser extent on shaded sandstone. With the lady fern it is the first to appear in the spring and it is not very sensitive to frost. It does not stand our dry summers well and often dries up, starting again when rain and cooler weather come. There is an extreme variation in vegetative features in different situations. Plants growing in loose soil in woods have long branching rhizomes and the growing point protrudes and is naked; on rock the growth is less luxuriant, the rhizome is short as is the growing point which is more or less covered with scales. Much sun causes prolific sporulation.

Cystopteris bulbifera (L.) Bernh. The bulblet fern grows in this area wherever its favorite habitat, moist shaded limestone, occurs. It is also found on shaded stream banks, especially in Kishwaukee River gorge. It grows less well on sandstone. Growth begins about April 1st. The young plants have red stipes which separate it in early infancy from *C. fragilis*. It is not subject to vegetative variations except that, its moisture requirement being high, drought causes depauperate plants.

Woodsia obtusa (Spreng.) Torr. The common woodsia is not common in this area. It is seldom found on limestone and here it does not grow on wooded hillsides to nearly the

extent that it does in more southern counties. It grows on a high sandy slough bank in Boone County and on limestone in White Pines State Park, but otherwise it is confined to the sandstone area of Ogle County. It is not uncommon on partly shaded cliffs but grows larger when in humus in woods. It is our only fern that grows throughout the winter. In the dry weather of late summer the plants may become dormant, the leaves turning yellowish and the edges curling back.

Woodsia ilvensis (L.) R. Br. The rusty woodsia is found in a number of stations in the sandstone area of Ogle County but it does not occur elsewhere in this region. It is often accompanied by *W. obtusa* which it does not resemble enough to be confusing. It grows about four inches tall in compact mats on the top edge of exposed outcrops so that it is not difficult to find. In one place in the sandstone area it grows on a shaded sandy hillside and here it is larger than in its typical situation. It can be found in winter by its characteristic stubble. It is sensitive to late frosts but quickly starts growing again. In dry weather it tends to curl but is quickly rejuvenated by rain.

Polystichum acrostichoides (Michx.) Schott. The Christmas fern has not been found by us in the area but there are specimens in the State Museum and University of Illinois herbaria from White Pines State Park in Ogle County. The nearest place outside this area that we have seen it is Starved Rack State Park in LaSalle County.

Dryopteris disjuncta (Leleb.) Morton. The oak fern grows on a moist partly shaded sandstone outcrop near Oregon in Ogle County with *Cornus canadensis, Trientalis borealis* and *Pinus strobus,* northern species which are very rare here. This station is probably the same from which M. B. Waite 60 years ago collected his specimens that are now in the University of Illinois herbarium. It is a small patch on a steep cliff, and the plants are healthy so its chances of continuing to survive are good. The nearest outside stations are in Green County, Wisconson, and in St. Clair County, Illinois.

Dryopteris phegopteris (L.) C. Chr. The long beech fern prefers wet shaded sandstone and is in such a situation in the two stations we have found in Ogle County where it is accompanied by *Viola pallens* which is rare here. Our plants do not look at all like *D. hexagonoptera.* The blade of *D. phegopteris* is definitely smaller and narrower, it has a distinctly yellow cast, and is more hairy. The croziers are very woolly and brown. It starts growing earlier than *D. spinulosa* and *D. intermedia.* The bending of the blade and the deflexion of the inferior pinnae are noticeable very early.

Dryopteris hexagonoptera (Michx.) C. Chr. The broad beech fern is found in one small station in a wooded ravine in the sandstone area of Ogle County. It is a much more robust plant than *D. phegopteris.* The winging of the rachis between the first and second pairs of pinnae is always so definite as to leave no doubt as to the species. The characteristic deflexion and turning forward and inward of the inferior pinnae is not seen in dried plants.

Dryopteris thelypteris (L.) Gray. The marsh fern in this region grows mostly in the bog areas of northern Winnebago and Boone Counties in its proper habitat, but we have also found it in abnormal situations such as a dry sunny sandstone outcrop in Camp Lowden, Ogle County, in a rather dry woods in White Pines State Park, and in Winnebago County, and on a dry railroad bank in Boone County. Under such conditions it sporulates sparingly and the blades are a different shape, the lower pinnae instead of being longer tend to shorten progressively and to become more remote, thus giving the appearance of *D. noveborensis;* but the veins are forked. Growth begins the latter part of April and the leaves are still very immature in early June. The sporophylls develop the latter part of July, abundantly in open wet places but less so in dry places or in the shade.

Dryopteris marginalis (L.) Gray. The marginal wood fern is found in this area only in White Pines State Park in Ogle County where the plants are large and healthy but are few. It is common at Starved Rock in LaSalle County and also occurs in Apple River Canyon State Park. The leaves stay green and erect all winter. The number of sori varies greatly on different plants without apparent cause.

Dryopteris cristata (L.) Gray. The crested wood fern grows in White Pines State Park and in a ravine near Oregon in Ogle County, in several places in Winnebago County but it is most abundant in the boggy area in northern Boone County. We have found it in woods and in ravines but for the most part it is a bog plant. There are never more than a few plants in one place. It is the first of the wood ferns to start growing in the spring. The sterile blades and the sterile part of partly fruited blades are evergreen. There is considerable difference in the length and width of the blades on different plants but otherwise there is no important variation.

Dryopteris intermedia (Muhl.) Gray. The common wood fern is not the common one in this region. It is found in all our counties, the distribution being much the same as of *D. spinulosa* but it is much less common than the latter. The gradation with *D. spinulosa* is not apparent in our plants. It tends to grow in drier plices; the leaf is more finely divided and is thinner; the shortening of the proximal inferior pinnule on the lowest pinna is definite, and the leaves of this plant do not flop over so quickly after freezing. Spring growth starts after April 15th.

Dryopteris spinulosa (O. F. Muell.) Watt. The spinulose wood fern grows in moist woods and ravines in all our counties. We have found it in a bog in the open in northern Boone County. Robust plants have broad blades and the lower proximal pinnule on the basal pinna is much enlarged and elongated but there is no sharp dividing line between this and the typical form in our area. This fern starts growth the same time as *D. intermedia.* After the first hard frost the plant is inactive until spring, the bases of the stems soften and the leaves lie flat on the ground, staying green all winter. It is a coarser looking plant than *D. intermedia.*

Polypodium virginianum L. The common polypody in this area is abundant on the sandstone in Ogle County but otherwise we have found it in only one small station, in a limestone situation in Kishwaukee River gorge in Winnebago County. Its vegetative characters are not subject to variation. Growth starts about April 1st, the fronds being well uncoiled when still quite small.

Camptosorus rhizophyllus (L.) Link. The walking fern is found in all the counties of this area on moist shaded limestone. We have found it growing on sandstone on Franklin Creek in Lee County. In one of our largest stations in a Kishwaukee River ravine where the environment seems correct it is of a depauperate type, the plant having a juvenile appearance with blunt blades. In dry situations the edges of the blades are wavy and irregular. We have found but few blades lacking auricles. It is evergreen and spring growth starts about April 1st.

Asplenium platyneuron (L.) Oakes. The ebony spleenwort is quite uncommon in this area. We have found it in several places in Ogle County and in Boone County. Many years ago we found it in Winnebago County but we are now unable to locate it. Its favorite habitat here is shaded sandstone, but on Castle Rock in what looks like a favorable situation it is small compared with those growing in woods in a limestone area in White Pines State Park.

Athyrium angustum (Willd.) Presl. The lady fern is a common fern here, growing in practically all moist woods, in ravines, at the edge of open marshy places, and by accident on cliffs. There is a great variation in the size of the plants, the color of the stipes, cutting of the blades, size and shape of the sori, etc., which seems to depend on environmental conditions. Though the first with *Cystopteris fragilis* to start growing in the spring, it is very tender to fall frosts. It does not withstand hot dry weather.

Athyrium thelypterioides (Michx.) Desv. The silvery glade fern is known in our area from Winnebago and Ogle Counties. The nearest outside station that we know is Mississippi Palisades State Park. In our plants the lower surface of the pubescent. This and the silvery streaks the sori make very early in their development are the most noticeable field points.

Cryptogramma stelleri (S. G. Gmel.) Prantl. The slender cliff brake is found across northern Illinois wherever its habitat, moist shaded limestone, occurs. It is in all our counties. We have not found it in Kishwaukee River gorge in places that look favorable. It is our smallest and most fragile fern. It is difficult to find, for though it starts to grow early in April, the sterile blades have begun to turn yellow by late May and soon disappear. The sporophylls are a little more persistent but by the last of July they are very hard to find. In a mild wet fall a second growth of sterile leaves appears in October.

Pellaea glabella Mett. The smooth cliff brake is found in this area on practically all exposed limestone outcrops. It also grows on small rocks on hillsides, in railroad cuts, in old quarries and on bridge abutments. It is evergreen in the sense that it

retains its peculiar bluish green color well into the second year. After the pinnules are shed the old stipes persist stiffly erect for years. It prefers a dry exposed situation but if the cliff is excessively dry the plants though plentiful are small. When it grows in a moist shady place the plants are larger and more abundant. We have found it growing on sandstone only once, on the river side of Castle Rock in Ogle County where it is of a depauperate type. Growth starts about April 1st, the leaves developing slowly.

Adiantum pedatum L. The Maidenhair fern grows in large or small patches in most of the moist rich woods in this area but it is strangely absent from some woods that seem suitable. It occurs by accident on moist cliffs. Growth starts early in April and it is the last of our deciduous ferns to be killed by frost in the fall. It is not subject to variations except as to size.

Pteridium latiusculum (Desv.) Hieron. The bracken is another common fern which is generally distributed over this area, growing preferably in sandy oak woods but also along roadsides, railroads, and in brushy pastures. It spreads rapidly and forms large patches. It is a stately plant that starts to grow about April 1 by the appearance of three greenish balls on a stem which are very sensitive to frost, so it is not uncommon in a late spring for several starts to be made. This does not seem to retard the later development of the plant. The cutting of the leaves varies from plant to plant and even on the same rhizome. Variations are not sufficient to justify separation into varieties. It is our one fern that is truly a weed.

Summary

The geography and topography of a well defined area in northern Illinois, the drainage basin of Rock River, is described and some account of the habitats and fern inhabitants of the area is given.

The frequency of occurrence and distribution of each of the 31 species that we know to grow in the area are given.

Some comments are made about the growth habits and the local peculiarities of each of the species as observed in the field.

EMBRYO DEVELOPMENT OF THE POND CYPRESS (*TAXODIUM ASCENDENS BRONGN.*)*

MARGARET KAEISER
Southern Illinois University, Carbondale

Collections of material for this study were made in Collier County, Florida, along the Tamiami Trail (U. S. Highway 94) in August of 1947 and May of 1948. Since it has been stated (Davis, 1943) that the pond cypress, *Taxodium ascendens* Brongn., growing in this region could possibly be a variety of the bald cypress, *T. distichum* (L.) Rich., care was used in the examination of all trees sampled. Rehder (1947) makes use of the differences in the leaf shape and arrangement and habit of growth of the branchlets in separating these two plants in his manual and recognizes *T. ascendens* as a valid species. Certainly the subulate leaves, incurved and closely appressed to the twigs, and the more upright growth of the branchlets of the pond cypress are all characteristics in marked contrast to the linear, spreading, two-ranked leaves and the more horizontal growth of branchlets of the bald cypress (Plate I).

The May 1948 collections were used for study of proembryo and early embryo stages, and the August 1947 collections provided material for matured seed and cotyledon counts. Megagametophytes containing proembryo stages were killed and fixed in F.A.A., sectioned ten microns in thickness and stained with Haidenhain's haemotoxylin and Orange G. Embryos in later stages were dissected and prepared according to the method used by Buchholz (1936). Terminology follows that of Buchholz (1946). The embryo pattern of development closely parallels that of *T. distichum* (Kaeiser, 1940).

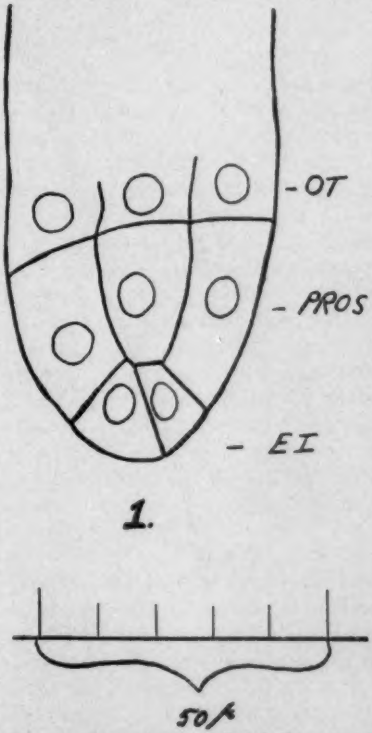


FIG. 1.—Proembryo of Pond Cypress, *T. ascendens*. OT, open tier of cells; PROS, prosuspensor; EI, embryo initials.

* Aided in part through a University Research Grant, Southern Illinois University, Carbondale. The writer also wishes to thank Miss Esther S. Sayers for assistance in collecting material.

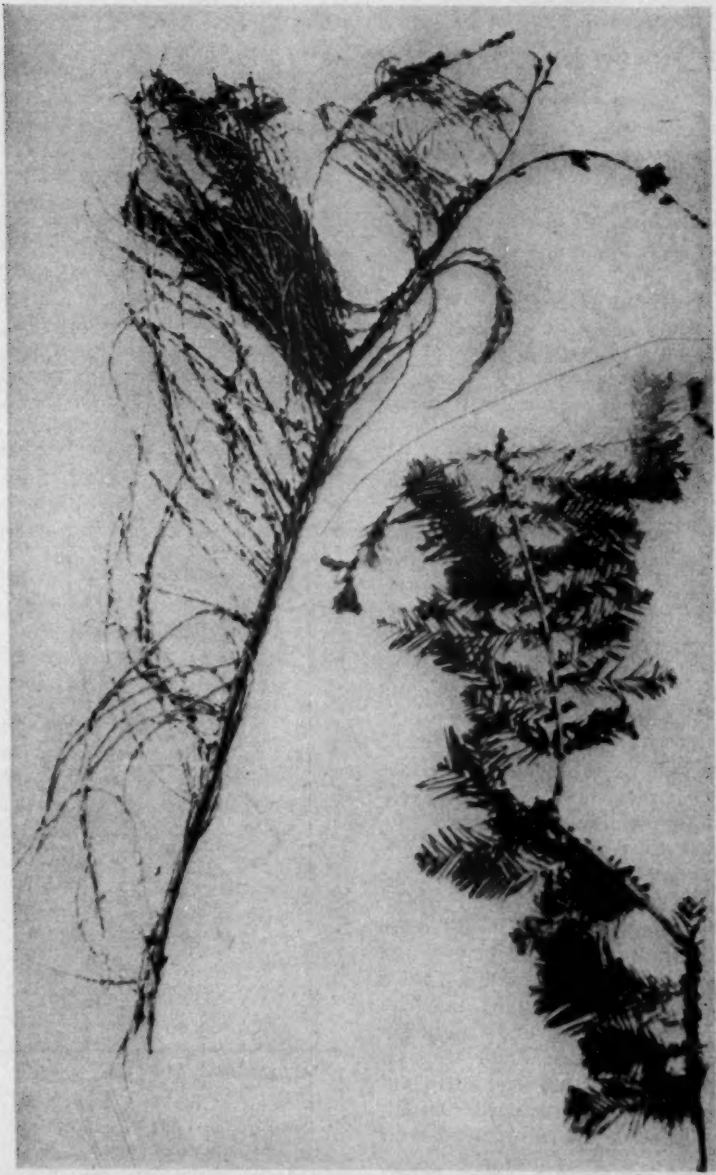


PLATE I.—Left, Leaf and branchlet arrangement in *T. ascendens* Brongn. Right. Leaf and branchlet arrangement in *Taxodium distichum* (L.) Rich.

Proembryos were obtained of the stage shown in Figure 1. There is no rosette tier. The open tier (OT) has six cells. The prosuspensor tier (PROS) consists of six cells. At the bottom of the archegonium four embryo initials (EI) are present. The proembryo at this stage occupies approximately the lower one-third of the archegonium. The embryo initials are frequently arranged in tetrahedral fashion (Figs. 2, 2a, 2b). This organization is similar to that found in *T. distichum*. There is no primary suspensor system.

Of almost one hundred archegonial complexes examined which showed any subsequent development of embryos, the number of embryo systems of which each was developed from one proembryo ranged from one to four per archegonial complex. Most dissections revealed two or three separate embryo systems per archegonial complex. These resulted from separate fertilizations and are indicative of simple polyembryony.

The prosuspensor cells elongate and push through the lower portion of the archegonium. Some elongation is already apparent in Figure 1. They are often much coiled and twisted. Occasionally one or more may appear separated from the embryo initials (Fig. 2a). No other cell or cells appear to arise from these isolated prosuspensor cells.

The open tiers of nuclei, incompletely separated by walls, are transitory. Their nuclei had disintegrated in the later stages studied.

Figure 3 shows early divisions of the four embryo initials (EI) of one embryo system. Each unit is to be regarded as a separate embryo. This is an early indication of cleavage polyembryony.

Later stages in development of individual embryos appeared as shown in Figures 4-6. Figures 4 and 5 show the formation of embryonal tubes (ET). The embryonal tubes, formed by divisions of the embryo initials, form a secondary suspensor system.

Even in comparatively early stages of development of embryos from one embryo system, one of the embryos is usually larger in size, as shown in Figure 6. This figure shows only approximately one-third of the extensive prosuspensor.

In only one case of dissection of matured seeds was there found more than one embryo. (This would be indicative of simple polyembryony were it not for cleavage polyembryony which becomes manifest very soon.) In this case there was great discrepancy in size of the two embryos present within the megagametophyte and both appeared to be attached to the same prosuspensor system. In archegonial complexes examined that contained the sixteen-celled proembryos within the archegonia, it was noted that elongation of some of the prosuspensors was more advanced in some embryo systems than in others within the same complex. Embryo initials of some more advanced systems were also found to be more deeply imbedded in the gametophyte than were their neighbors from adjacent archegonia because of the greater elongation of their prosuspensors. These observations would suggest that the early rapid growth (elongation) of the prosuspensor cells of any one embryo system, as well as the earlier pre-

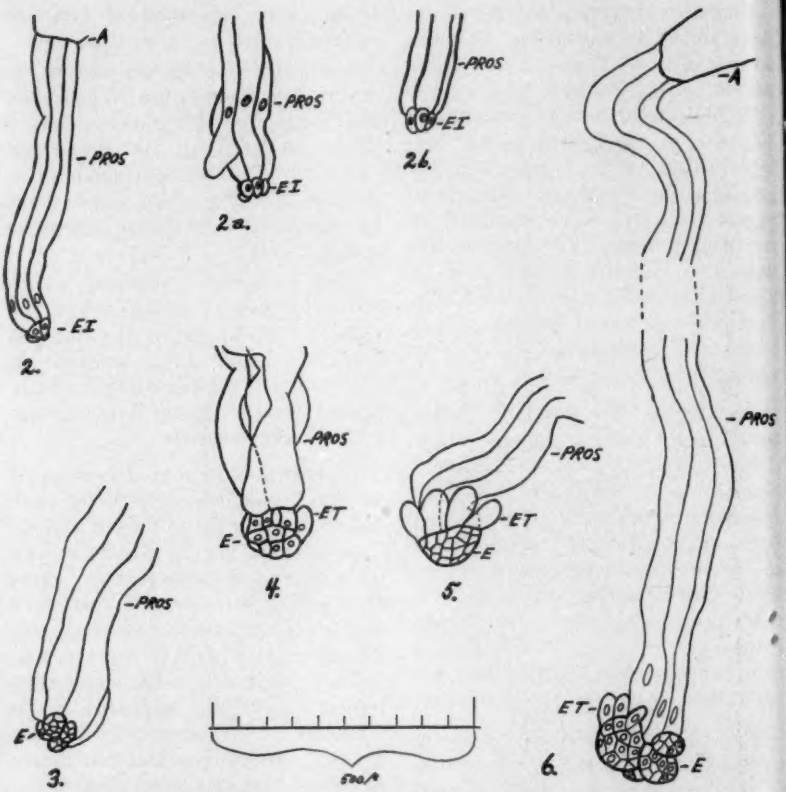


FIG. 2.—One embryo system showing elongated prosuspensor. A, archegonium; PROS, prosuspensor; EI, four embryo initials.

FIG. 2a.—Lower portion of one embryo system showing one of four prosuspensor (PROS) cells detached from embryo initials (EI).

FIG. 2b.—Lower portion of one embryo system showing three of four prosuspensor (PROS) cells and characteristic tetrahedral arrangement of embryo initial cells (EI).

FIG. 3.—Lower portion of one embyro system showing four prosuspensor cells (PROS) and four individual embryos (E). Early indication of cleavage polyembryony.

FIG. 4.—Later stage of embryo development (E) showing one embryonal tube (ET) of secondary suspensor system. PROS, prosuspensor.

FIG. 5.—Similar to Fig. 4, with additional embryonal tubes. PROS, prosuspensor; ET, embryonal tubes; E, embryo.

FIG. 6.—Approximately one-third of elongated prosuspensor shown. Note larger size of one embryo showing early stage in development of secondary suspensor system (ET). A, archegonium; PROS, prosuspensor; ET, one of several embryonal tubes attached to largest embryo; E, one of four embryos.

dominance in size of one of its embryos, are among the critical factors in determining which embryo shall ultimately survive.

The matured embryo closely resembles that of *T. distichum*.

Of five hundred seeds of *T. ascendens* selected at random from cones collected in August 1948, only 8.4 percent contained embryos. Of these matured embryos examined the number of cotyledons per embryo varied from five to seven with 69.04 percent showing six. Similar counts made of *T. distichum* (Kaeiser, 1940) from Arkansas yielded 16.6 percent good seeds, although 45 percent has been reported by R. M. Fisher of the Thompson Tree Nursery of Jonesboro, Illinois, for crops previous to 1939 in southern Illinois.* The cotyledon counts made by the author on three hundred *T. distichum* seedlings showed a range of four to eight with the majority showing six. The low percentage of pond cypress seeds with embryos might possibly be explained on an environmental basis. In the regions where collections were made the plants are referred to as "scrub cypress" and are of generally smaller growth than *T. distichum* (Davis, 1943).

* Personal correspondence.

LITERATURE CITED

BUCHHOLZ, J. T. 1936—The Dissection, Staining, and Mounting of the Embryos of Conifers. Stain Tech. 13: 53-64.

———. 1946—Gymnosperms. Ency. Brit.

DAVIS, JOHN H., JR. 1943—The Natural Features of Southern Florida. State of Fla. Dept. of Conservation. Geol. Bull. No. 25. Tallahassee.

KAEISER, MARGARET. 1940—Morphology and Embryogeny of the Bald Cypress, *Taxodium distichum* (L.) Rich. Ph.D. Thesis, Univ. of Ill.

REHDER, ALFRED. 1947—Manual of Cultivated Trees and Shrubs. Macmillan Co. New York.

CHECK LIST OF THE VASCULAR PLANTS OF WINNEBAGO COUNTY, ILLINOIS

GEORGE D. FULLER, EGBERT W. FELL, and GEORGE B. FELL
Illinois State Museum, Springfield

Winnebago County is in the center of the northern boundary of the State of Illinois. It is traversed by the Rock River and two of its principal tributaries—the Kishwaukee and the Pecatonica—and Sugar River, a tributary of the Pecatonica, flows into the county from Wisconsin. Most of the county has moderate topography, the elevation ranging from 680 to 990 feet above sea level. The northwest corner is more hilly than the rest of the area.

Most of the county is covered by glacial drift which was deposited by the ice-sheet of the Illinoian glacial period. The Wisconsin ice-sheet, with its border to the north and east, contributed extensive terraces of glacial outwash gravel which filled the major stream valleys, in some places to a depth of more than 250 feet. The Belvidere lobe of the Early Wisconsin glaciation extended into the southeast corner of the county, cutting off the former valley of the Kishwaukee River and causing the stream to flow along the north edge of the glacier where it eroded a gorge in the bedrock about a hundred feet deep and several miles long. The lobe of ice also blocked the Rock River and caused it to form a new channel to the west of its former one, seen at Byron in Ogle County. Here, too, a gorge was cut into the bedrock, but not so clearly defined as along the Kishwaukee.

There are small outcrops of bedrock at a number of other widely scattered places in the county where streams have eroded new channels through the glacial drift. Some of the hilltops, especially in the west part of the area, are devoid of glacial drift and have rock directly beneath the soil. All of these outcrops are Galena dolomite except a small exposure of St. Peter sandstone on the east bank of Sugar River. The area bounded by the Sugar, Pecatonica, and Rock rivers consists largely of sandy soil and dune sand. The geography and geology of the county have been described in detail by various authors of the Illinois Geological Survey (2, 10, 11).

Like most of Illinois, in Winnebago County the vegetation consisted of a mixture of prairie and deciduous forest. The forest vegetation was mostly concentrated above the Pecatonica River and along the south and east boundaries of the county. The central area was largely prairie. The soil survey (6) shows accurately the limits of the soils formed under prairie and forest conditions.

The plant associations and habitats may be divided roughly into the following groups: forest, of which at least one area is predominantly sugar maple, others which were largely oak; prairie, ranging from low wet areas to dry hills; bogs, mainly sedge, but with several Sphagnum areas; swamps, especially along the Pecatonica River; streams; limestone outcrops; and sand. A num-

ber of unusual northern species of plants can be found in the bog and rock outcrop areas.

Agriculturally, the county is on the boundary between the corn belt and dairy country. Cultivation and grazing have profoundly modified the entire vegetation except for a very few small areas, yet there remains a remarkably diverse flora.

The flora of the county has been studied by many botanists, beginning with Michael S. Bebb (1). Gleason (5), in 1910, reported on the Sugar River sand area vegetation. The Nature Study Society of Rockford published lists of the woody plants of the area (8, 9). More recently Dr. Fernald, of Rockford College, has reviewed the work of former botanists (3) and published a list of the herbaceous plants (not including the ferns) of the county (4).

As a part of the Rockford Museum Project of the W. P. A., Dr. Fernald directed the collection of more than 1,000 plants in the county during the seasons of 1939 and 1940. These were deposited in the herbarium of Rockford College, duplicates being given to the Illinois State Herbarium at Springfield.

During the last few year intensive study of the flora has been made by the junior authors and the collections thus obtained have been deposited in the herbarium of the Illinois State Museum, Springfield, and on these specimens this list is based with a few exceptions that are in the herbarium of the Chicago Natural History Museum and these exceptions have been checked by the senior author. There are also a few that are in the herbarium of Rockford College which are marked with an asterisk (*) but have been reported in the previously published lists.

The taxonomic arrangement and nomenclature follow Jones (7) with very few exceptions.

Lycopodiaceae
Lycopodium lucidulum Michx.

Selaginellaceae
Selaginella rupestris (L.) Spring.

Equisetaceae
Equisetum arvense L.
" laevigatum A. Br.
" prealtum Raf.

Ophioglossaceae
Botrychium dissectum Spreng.
" multifidum (Gmel.) Rupr.
" obliquum Muhl.
" virginianum (L.) Sw.

Osmundaceae
Osmunda cinnamomea L.
" claytoniana L.
" regalis L.

Polypodiaceae
Cystopteris bulbifera (L.) Bernh.
" fragilis (L.) Bernh.
Onoclea sensibilis L.
Dryopteris cristata (L.) Gray
" intermedia (Muhl.) Gray
" spinulosa (Muell.) Watt
" thelypteris (L.) Gray
Polypodium virginianum L.
Camptosorus rhizophyllus (L.) Link
Asplenium platyneuron (L.) Oakes
Athyrium angustum (Willd.) Presl.
" thelypteroides (Michx.) Desv.
Cryptogramma stelleri (Gmell.) Prantl.
Pellaea glabella Mett.
Adiantum pedatum L.
Pteridium latiusculum (Desv.) Hieron.

Taxaceae
Taxus canadensis Marsh.

Pinaceae
Pinus strobus L.
Juniperus virginiana L.

Typhaceae
Typha angustifolia L.
" latifolia L.

Sparganiaceae
Sparganium americanum Nutt.
" eurycarpum Engelm.

Potamogetonaceae
Potamogeton americanus C. & S.
" foliosus Raf.
" lucens L.
" pectinatus L.

Alismaceae
Alisma subcordatum Raf.
Sagittaria brevirostra Mack & Bush
" latifolia Willd.
" longirostra (Micheli) Sm.*

Hydrocharitaceae
Anacharis canadensis (Michx.) Planch.

Gramineae
Bromus ciliatus L.
" commutatus Schrad.*
" inermis Leyss
" kalmii Gray
" secalinus L.
" tectorum L.
Festuca obtusa Spreng.
" octoflora Walt.
Glyceria grandis Wats.
" septentrionalis Hitchc.*
" striata (Lam.) Hitchc.
Poa annua L.
" compressa L.
" palustris L.*
" pratensis L.
" sylvestris Gray
Eragrostis capillaris (L.) Nees.
" cilianensis (All.) Link
" frankii C.A. Mey
" hypnoides (Lam.) BSP
" pectinacea (Michx.) Nees.
" spectabilis (Pursh) Steud.
Diarrhena americana Beauv.
Dactylis glomerata L.
Phragmites communis Trin.
Triodia flava (L.) Smyth
Agropyron repens (L.) Beauv.
" smithii Rydb.
Elymus canadensis L.
" villosus Muhl.
" virginicus L.
Hystrix patula Moench.
Hordeum jubatum L.
Koeleria cristata (L.) Pers.
Arrehnatherum elatius (L.) Mert. & Koch.
Danthonia spicata (L.) Beauv.
Calamagrostis canadensis (Michx.) Beauv.
Calamovilfa longifolia (Hook.) Scribn.
Agrostis alba L.
" hiemalis (Walt.) BSP.
Cinna arundinacea L.
Phleum pratense L.
Alopecurus carolinianus Walt.
Muhlenbergia foliosa (R. & S.) Trin.
" mexicana (L.) Trin.
" schreberi Gmel.
Sporobolus cryptandrus (Torr.) Gray
" heterolepis Gray
" neglectus Nash.
Orzopsis asperifolia Michx.
" racemosa (Sm.) Ricker
Stipa comata Trin. & Rupr.*
" spartea Trin.
Aristida oligantha Michx.
" purpurascens Poir.*
" tuberculosa Nutt.
Eleusine indica (L.) Gaertn.
Spartina pectinata Link
Bouteloua curtipendula (Michx.) Torr.
Hierochloe odorata (L.) Beauv.*
Leersia oryzoides (L.) Sw.
" virginica Willd.
Zizania aquatica L.
Digitaria ischaemum (Schreb.) Muhl.
" sanguinalis (L.) Scop
Panicum capillare L.
" clandestinum L.*
" dichotomum L.
" dichotomiflorum Michx.
" huachucae Ashe
" latifolium L.
" perlongum Nash.*
" scribnerianum Nash.
" villosissimum Nash.
" virgatum L.
Echinochloa crus-galli (L.) Beauv.
" walteri (Pursh) Heller
Setaria lutescens (Weigel) Hubb.
" viridis (L.) Beauv.
Cenchrus longispinus (Hack.) Fern.
Andropogon furcatus Muhl.
" scoparius Michx.
Sorghastrum nutans (L.) Nash.

Cyperaceae
Cyperus aristatus Rottb.
" diandrus L.
" engelmannii Steud.
" esculentus L.
" ferruginescens Boeckl.
" filiculmis Vahl.
" houghtonii Torr.
" rivularis Kunth.
" schweinitzii Torr.
" strigosus L.
Dulichium arundinaceum (L.) Britt.
Eleocharis acicularis (L.) R. & S.
" compressa Sulliv.
" engelmannii Steud.
" obtusa (Willd.) Schult.
" ovata (Roth.) R. & S.
" palustris (L.) R. & S.
" quadrangulata (Michx.) R. & S.
" tenuis (Willd.) Schult.
Bulbostylis capillaris (L.) Clarke
Hemicarpa micrantha (Vahl.) Britt
Fimbristylis autumnalis (L.) R. & S.
Scirpus americanus Pers.
" atrovirens Muh.
" cyperinus (L.) Kunth.
" fluviatilis (Torr.) Gray*
" lineatus Michx.
" validus Vahl.
Eriophorum angustifolium Honck.
" virginicum L.
Rhynchospora alba (L.) Vahl.
Scleria triglomerata Michx.
Carex aurea Nutt.
" bebbii Olney
" bicknellii Britt.
" blanda Dewey
" buxbaumii Wahl.
" cephaloidea Dewey
" cephalophora Muhl.
" chordorrhiza Ehrh.*
" comosa Boott.
" conoidea Schkuhr.
" cristatella Britt
" crus-corvi Shuttlew

Carex davisii Schw. & Torr.
" festucacea Schk.*
" filiformis L.
" gracillima Schw.
" granularis Muhl.
" gravida Bailey
" grisea Wahl.
" grayii Carey
" hirtifolia Mack.*
" hystricina Muhl.
" interior Bailey
" lanuginosa Michx.
" laxiflora Lam.
" longirostris Torr.
" lupulina Muhl.
" lurida Wahl.
" muskingumensis Schw.*
" muhlenbergii Schk.
" pennsylvanica L.
" plantaginea Lam.
" pseudo-cyperus L.
" retrorsa Schwein.*
" richardsonii R. Br
" rostrata Stokes
" rosea Schk.
" scoparia Schk.
" shortiana Dewey
" sparganoides Muhl.*
" sprengelii Dewey
" stipata Muhl.
" straminea Willd.
" stricta Lam.
" tenera Dewey
" tribuloides Wahl.
" tuckermannii Dewey*
" varia Muhl.
" virescens Muhl.
" vulpinoidea Michx.

Araceae

Arisaema atrorubens (Ait.) Blume
" dracontium (L.) Schott.
Symplocarpus foetidus (L.) Nutt.
Acorus calamus L.

Lemnaceae

Lemna minor L.
" trisulca L.
Spirodela polyrhiza (L.) Schleiden

Xyridaceae

Xyris torta Sm.

Commelinaceae

Commelina communis L.
" virginica L.
Tradescantia canaliculata Raf.
" virginiana L.

Pontederiaceae

Pontederia cordata L.
Heteranthera dubia (Jacq.) MacM.

Juncaceae

Juncus acuminatus Michx.
" balticus var. littoralis Engelm.
" dudley Wieg.
" effusus L.
" greenei Oakes & Tuck.
Juncus interior Wieg.
" macer S. F. Gray
" marginatus Rostk.
" nodosus L.
" scirpoides Lam.
" vaseyi Engelm.
Luzula multiflora (Ehrh.) Lej.

Liliaceae

Hemerocallis fulva L.
Allium canadense L.
" cernuum Roth.
" tricoccum Ait.
Asparagus officinalis L.
Camassia scillioides (Raf.) Cory
Erythroniumllalbidum Nutt
" americanum Ker.
Lilium michiganense Farw.
" umbellatum Pursh
Maianthemum canadense var. interius Fern.
Ornithogalum umbellatum L.
Polygonatum biflorum (Walt.) Ell.
Uvularia grandiflora Sm.
Trillium gleasoni Fern.
" recurvatum Beck.
Smilacina racemosa (L.) Desf.
" stellata (L.) Desf.
Smilax ecirrhata (Engelm.) Wats.
" lasioneuron Hook.
" hispida Muhl.
" rotundifolia L.

Dioscoreaceae

Dioscorea villosa L.

Amaryllidaceae

Aletris farinosa L.
Hypoxis hirsuta (L.) Coville

Iridaceae

Belamcanda chinensis (L.) DC
Iris shrevei Small
Sisyrinchium albidum Raf.
" angustifolium Mill.
" graminoides Bickn.

Orchidaceae

Cypripedium candidum Muhl.
" parviflorum Salisb.
" reginae Walt.
Orchis spectabilis L.
Habenaria bracteata (Muhl.) R. Br.
" lacera (Michx.) Lodd.
" leucophaea (Nutt.) Gray
" psycodes (L.) Spreng.
Calopogon pulchellus (Salisb.) R. Br.
Triphora trianthophora (Sw.) Rydb.
Spiranthes cernua (L.) Rich.
Goodyera pubescens (Willd.) R. Br.
Liparis liliifolia (L.) Rich.
Aplectrum hyemale (Muhl.) Torr.
Corallorrhiza maculata Raf.

Salicaceae

Populus alba L.
" deltoides Marsh.
" grandidentata Michx.
" tremuloides Michx.

Salix amygdaloides Anders.
" bebbiana Sarg.
" candida Fluegge.
" cordata Muhl.
" discolor Muhl.
" fragilis L.
" glaucophylla Bebb.
" humilis Marsh.
" interior Rowlee
" lucida Muhl.
" nigra Marsh.
" pedicellaris Pursh.*
" petiolaris Sm.
" sericea Marsh.
" tristis Ait.

Juglandaceae
Juglans cinerea L.
" nigra L.
Carya cordiformis (Wang.) K. Koch.
" ovata (Mill.) K. Koch.

Betulaceae
Alnus incana (L.) Moench.
Corylus americana Walt.
Ostrya virginiana (Mill.) Koch.
Carpinus caroliniana Walt.
Betula lutea Michx. f.
" glandulifera (Regel) Butler
" pumila L.

Fagaceae
Quercus alba L.
" bicolor Willd.
" borealis Michx. f.
" ellipsoidalis Hill
" macrocarpa Michx.
" muhlenbergia Engelm.
" palustris Muench.
" velutina Lam.

Ulmaceae
Ulums americana L.
" fulva Michx.
Celtis occidentalis L.
Morus rubra L.

Cannabinaceae
Cannabis sativa L.
Humulus americanus Nutt.

Urticaceae
Urtica procera Muhl.
Boehmera cylindrica (L.) Sw.
Pilea pumila (L.) Gray
Laportea canadensis (L.) Gaud.
Parietaria pennsylvanica Muhl.

Santalaceae
Comandra umbellata (L.) Nutt.

Aristolochiaceae
Asarum acuminatum (Ashe) Bickn.
" reflexum Bickn.

Polygonaceae
Rumex acetosella L.
" altissimus Wood
" britannica L.
" crispus L.
" orbiculatus Gray
" verticillatus L.
Polygonum aviculare L.
" buxiforme Small
" coccineum Muhl.
" convolvulus L.
" hydropiper L.
" hydropiperoides Michx.
" lapathifolium L.
" orientale L.
" natans (Michx.) Eaton
" pennsylvanicum L.
" persicaria L.
" punctatum Ell.
" ramosissimum Michx.
" scandens L.
" sagittatum L.
" tenue Michx.
" virginianum L.
Polygonella articulata (L.) Meis.

Chenopodiaceae
Chenopodium album L.
" berlandieri Moq.*
" boscianum Moq.
" capitatum L.
" glaucum L.
" hybridum L.
" leptophyllum Nutt.*
" urbicum L.
Kochia scoparia (L.) Schrad.
Atriplex patula L.
Salsola pestifer A. Nels.

Amaranthaceae
Amaranthus blitoides Wats.
" graecizans L.
" hybridus L.
" retroflexus L.
" spinosus L.
Acnida altissima Riddell
" tamariscina (Nutt.) Wood.
Froelichia gracilis Moq.

Phytolaccaceae
Phytolacca americana L.

Nyctaginaceae
Mirabilis nyctaginea (Michx.) MacM.

Illecebraceae
Paronychia canadensis (L.) Wood
Scleranthus annuus L.

Aizoaceae
Mollugo verticillata L.

Portulacaceae
Talinum rugospermum Holz.
Claytonia virginica L.
Portulaca oleracea L.

Caryophyllaceae
Cerastium nutans Raf.
" vulgatum L.
Stellaria aquatica (L.) Scop.
" longifolia Muhl.
" media (L.) Cyril.
Arenaria lateriflora L.
" serpyllifolia L.
" stricta Michx.
Agrostemma githago L.

Silene antirrhina L.
" cucubalus Wibel.
" dichotoma Ehrh.
" nivea (Nutt.) Otth.
" noctiflora L.
" stellata (L.) Ait.
Lychnis alba Mill.
Saponaria officinalis L.
" vaccaria L.

Ranunculaceae
Caltha palustris L.
Hydrastis canadensis L.
Isopyrum biternatum (Raf.) T. & G.
Aquilegia canadensis L.
Actaea alba (L.) Mill.
" rubra (Ait.) Willd.
" rubra var. neglecta Gill.
Ranunculus abortivus L.
" acnis L.
" fascicularis Muhl.
" flabellaris Raf.
" hispidus Michx.
" pennsylvanicus L. f.
" recurvatus Poir.
" repens L.
" rhomboideus Goldie
" sceleratus L.
" septentrionalis Poir.
" trichophyllus Chaix.
Thalictrum dasycarpum F. & L.
" dioicum L.
" revolutum DC.
Anemone canadensis L.
" caroliniana Walt.
" cylindrica Gray
" ludoviciana Nutt.
" quinquefolia L.
" virginiana L.
Anemonella thalictroides (L.) Spach.
Hepatica acutiloba DC.
" americana (DC.) Ker.
Clematis virginiana L.

Nymphaeaceae
Nuphar advena Ait.
Nymphaea tuberosa Paine

Berberidaceae
Podophyllum peltatum L.
Jeffersonia diphylla (L.) Pers.
Caulophyllum thalictroides (L.) Michx.

Menispermaceae
Menispermum canadense L.

Lauraceae
Lindera benzoin (L.) Blume

Papaveraceae
Sanguinaria canadensis L.

Fumariaceae
Dicentra canadensis (Goldie) Walp.
" cucullaria (L.) Bernh.
Corydalis flavula (Raf.) DC.
" montana Engelm.
Fumaria officinalis L.

Cruciferae
Allaria officinalis Andrz.
Brassica alba (L.) Rabenh.
" arvensis (L.) Raben.
" campestris L.
" juncea (L.) Cosson
" nigra (L.) Koch.
Diplotaxis muralis (L.) DC.
Rorippa palustris (L.) Bess.
" sessiflora (Nutt.) Hitchc.
" sylvestris (L.) Besser
Sisymbrium altissimum L.
" officinale (L.) Scop.
Conringia orientalis (L.) Dum.
Erysimum cheiranthoides L.
" inconspicuum (Wats.) MacM.
Hesperis matronalis L.
Descurainia brachycarpa (Rich.) Schulz.
Draba reptans (Lam.) Fern.
Dentaria laciniata Muhl.
Iodanthus pinnatifidus (Michx.) Steud.
Cardamine bulbosa (Schreb.) BSP.
" douglassii (Torr.) Britt.
" pennsylvanica Muhl.
Arabis canadensis L.
" confinis Wats.
" dentata T. & G.
" laevigata (Muhl.) Poir.
" lyrata L.
" pycnocarpa Hopkins
Arabidopsis thaliana (L.) Heynh.
Nasturtium officinale R. Br.
Armoracia aquatica (Eaton) Greene
" rusticana Gaertn.
Berteroa incana (L.) DC.
Camelina microcarpa Andrz.
Lepidium campestre (L.) R. Br.
" perfoliatum L.
" virginicum L.
Thlaspi arvense L.
Capsella bursa-pastoria (L.) Medic.

Capparidaceae
Polanisia graveolens Raf.
" trachysperma T. & G.

Crassulaceae
Penthorum sedoides L.

Parnassiaceae
Parnassia glauca Raf.

Saxifragaceae
Heuchera hispida Pursh
Mitella diphylla L.
Sullivantia renifolia Rosend.
Saxifraga pennsylvanica L.
" virginiana Michx.

Grossulariaceae
Ribes americanum Mill.
" cynosbati L.
" missouriense Nutt.
" odoratum Wendl.

Hamamelidaceae
Hamamelis virginiana L.

Platanaceae
Platanus occidentalis L.

Rosaceae
Physocarpus opulifolius (L.) Maxim.
Spiraea alba DuRoi
" tomentosa L.
Aruncus dioicus (Walt.) Fern.
Fragaria americana (Porter) Britt.
" virginiana Duch.
Potentilla anserina L.
" argentea L.
" arguta Pursh
" fruticosa L.
" monspeliensis L.
" palustris (L.) Scop.*
" recta L.
" simplex Michx.
Geum canadense Jacq.
" laciniatum Murr.
" strictum Ait.
" triflorum Pursh
Agrimonia gryposepala Wallr.
" parviflora Ait.
" pubescens Wallr.
" rostellata Wallr.
Rubus allegheniensis Porter
" flagellaris Willd.
" hispidus L.
" occidentalis L.
" pubescens Raf.
" strigosus Michx.
" spp.
Rosa blanda Ait.
" carolina L.
" palustris Marsh.
" suffulta Greene
Amelanchier arborea (Michx. f.) Fern.
" laevis Wieg.
" spicata (Lam.) K. Koch.
Pyrus communis L.
Malus ioensis (Wood) Britt.
Aronia melanocarpa (Michx.) Ell.
" prunifolia (Marsh.) Rehd.
Crataegus calpodendron (Ehrh.) Medic.
" locuples Sarg.
" mollis (T. & G.) Scheele
" pedicellata Sarg.
" pruinosa (Wendl.) K. Koch.
" punctata Jacq.
" succulenta Link
Prunus americana Marsh.
" lanata (Sudw.) M. & B.
" nigra L.
" pumila L.
" pennsylvanica L.
" serotina Ehrh.
" virginiana L.

Leguminosae
Desmanthus illinoensis (Michx.) MacM.
Gymnocladus dioica (L.) K. Koch.
Gleditsia triancanthos L.
Cassia fasciculata Michx.
" hebecarpa Fern.
Baptisia leucantha T. & G.
" leucophaea Nutt.
Lupinus perennis L.
Trifolium arvense L.
" hybridum L.
" pratense L.
" procumbens L.
" repens L.
Melilotus alba Desr.
" officinalis (L.) Lam.
Medicago lupulina L.
" sativa L.
Psoralea tenuiflora Pursh
Amorpha canescens Pursh
" fruticosa L.
Petalostemum candidum (Willd.) Michx.
" purpureum (Vent.) Rydb.
Tephrosia virginiana (L.) Pers.
Robinia pseudoacacia L.
Caragana arborescens Lam.
Astragalus canadensis L.
Desmodium canadense (L.) DC.
" canescens (L.) DC.
" dillenii Darl.
" glutinosum (Muhl.) Wood
" illinoense Gray
" nudiflorium (L.) D.C.
" paniculatum (L.) DC.
Lespedeza capitata Michx.
" hirta (L.) Horn.
" intermidia (Wats.) Britt.
" repens (L.) Bart.
" violacea (L.) Pers.
Vicia americana Muhl.
" caroliniana Walt.
" cracca L.*
" sativa L.
" villosa Roth.
Lathyrus myrtifolius Muhl.
" ochroleucus Hook.
" plaustris L.
" venosus Muh.
Apios americana Medic.
Strophostyles helvola (L.) Britt.
Amphicarpa bracteata (L.) Fern.
" comosa (L.) G. Don.

Geraniaceae
Geranium carolinianum L.
" maculatum L.
" sibiricum L.

Oxalidaceae
Oxalis corniculata L.
" cymosa Small
" stricta
" violacea L.

Linaceae
Linum sulcatum Riddell
" medium (Planch.) Britt.
" usitatissimum L.

Balsaminaceae
Impatiens biflora Walt.
" pallida Nutt.

Limnanthaceae
Floerkea proserpinacoides Willd.

Rutaceae
Zanthoxylum americanum Mill.
Ptelea trifoliata L.

Polygalaceae
Polygala cruciata L.
" incarnata L.
" polygama Walt.
" sanquinea L.
" senega L.
" verticillata L.

Euphorbiaceae
Acalypha virginica L.
Euphorbia commutata Engelm.
" corollata Pursh
" cyparissias L.
" esula L.
" geyeri Engelm.
" humistrata Engelm.*
" maculata L.
" marginata Pursh
" obtusata Pursh
" peplus L.
" polygonfolia L.
" supina Raf.
Poinsettia dentata (Michx.) Small
" heterophylla (L.) Small

Callitrichaceae
Callitriche heterophylla Pursh
" palustris L.

Celastraceae
Euonymus atropurpureus Jacq.
" obovatus Nutt.
Celastrus scandens L.

Aquifoliaceae
Ilex verticillata (L.) Gray

Anacardiaceae
Rhus aromatica Ait.
" arenaria (Greene) Jones
" glabra L.
" radicans L.
" typhina L.

Staphyleaceae
Staphylea trifolia L.

Aceraceae
Acer nigrum Michx. f.
" negundo L.
" rubrum L.
" saccharum Marsh.
" saccharinum L.

Rhamnaceae
Rhamnus cathartica L.
" frangula L.
" lanceolata Pursh
Ceanothus americanus L.
" ovatus Desf.

Vitaceae
Vitis aestivalis Michx.
" riparia Michx.
" vulpina L.
Parthenocissus quinquefolia (L.) Planch.

Tiliaceae
Tilia americana L.

Malvaceae
Malva rotundifolia L.
Callirhoe triangulata (Leav.) Gray
Napaea dioica L.
Sida spinosa L.
Abutilon theophrasti Medic.
Hibiscus trionum L.

Hypericaceae
Hypericum canadense L.
" ellipticum Hook.
" mutilum L.
" perforatum L.
" prolificum L.
" punctatum Lam.
" sphaerocarpum Michx.
Sarothra gentianoides L.
Triadenum virginicum (L.) Raf.

Cistaceae
Helianthemum canadense (L.) Michx.
" bicknellii Fern.
Lechea leggettii Britt. & Hollick
" stricta Legg.
" tenuifolia Michx.
" villosa Ell.

Violaceae
Viola canadensis L.
" conspersa Reich.
" cucullata Ait.
" eriocarpa Schw.
" fimbriatula Sm.
" lanceolata L.
" nephrophylla Greene
" pallens (Banks) Brain.
" papilionacea Pursh
" pedata L.
" pedatifida Don.
" pubescens Ait.
" sagittata Ait.
" striata Ait.
" sororia Willd.

Cactaceae
Opuntia rafinesquii Engelm.

Thymeleaceae
Dirca palustris L.

Lythraceae
Rotala ramosior (L.) Koehne
Ammania coccinea Rottb.
Decodon verticillatus (L.) Ell.*
Lythrum alatum Pursh
" salicaria L.

Onagraceae
Epilobium adenocaulon Hauss.
" augustifolium L.
" coloratum Muhl.
" leptophyllum Raf.
" strictum Muhl.
Ludwigia alternifolia L.
" palustris (L.) Ell.
" polycarpa S. & P.
Oenothera biennis L.
" laciniata Hill.
" pumila L.

Oenothera rhombipetala Nutt.
" speciosa Nutt.
Gaura biennis L.
Circaea latifolia Hill

Haloragidaceae

Myriophyllum heterophyllum Michx.
" verticillatum L.
Proserpinaca palustris L.

Cornaceae

Cornus alternifolia L. f.
" obliqua Raf.
" racemosa Lam.
" rugosa Lam.
" stolonifera Michx.

Araliaceae

Aralia nudicaulis L.
" racemosa L.
Panax quinquefolium L.

Umbelliferae

Eryngium yuccifolium Michx.
Daucus carota L.
Sanicula canadensis L.
" gregaria Bickn.
" marilandica L.
" trifoliata Bickn.
Osmorhiza claytoni (Michx.) Clark
" longistylis (Torr.) DC.
Cryptotaenia canadensis (L.) DC.
Chaerophyllum procumbens (L.) Crantz.
Zizia aptera (Gray) Fern.
" aurea (L.) Koch.
Taenidia integerrima (L.) Drude
Sium suave Walt.
Cicuta bulbifera L.
" maculata L.
Thaspium sylvaticum (Benke) Jones
" barbinode (Michx.) Nutt.
Polytaenia nuttallii DC.
Angelica atropurpurea L.
Heracleum lanatum Michx.
Pastinaca sativa L.
Coniosclinum chinense (L.) BSP.
Oxypolis rigidor (L.) Raf.
Carum carvi L.

Ericaceae

Chimaphila corymbosa Pursh
Pyrola elliptica Nutt.
" secunda L.
Monotropa uniflora L.
Gaylussacia baccata (Wang.) K. Koch.
Arctostaphylos uva-ursi (L.) Spreng.
Vaccinium angustifolium Ait.
" canadense Richards
" corymbosum L.

Primulaceae

Androsace occidentalis Pursh
Trientalis borealis Raf.
Lysimachia ciliata L.
" lanceolata Walt.
" nummularia L.
" quadriflora Sims.
" quadrifolia L.
" terrestris (L.) BSP.
Lysimachia thyrsiflora L.
" vulgaris L.
Dodecatheon meadia L.

Oleaceae

Fraxinus americana L.
" lanceolata Borkh.
" nigra Marsh.
" pennsylvanica Marsh.
" quadrangulata Michx.

Gentianaceae

Gentiana andrewsii Griseb.
" crinita Froel.
" flavida Gray
" procera Holm.
" puberula Michx.
" quinquefolia L.
" saponaria L.
Bartonia virginica (L.) BSP.
Nymphoides peltatum (Gmel.) Britten & Rendle

Apocynaceae

Apocynum androsaemifolium L.
" cannabinum L.
" pubescens R. Br.
" sibericum Jacq.*

Asclepiadaceae

Asleepias amplexicaulis Sm.
" incarnata L.
" phytolaccoides Pursh
" purpurascens L.
" pulchra Ehrh.
" quadrifolia Jacq.
" sullivantii Engelm.
" syriaca L.
" tuberosa L.
" verticillata L.
Acerates hirtella Pennell.
" languinosa Nutt.
" viridiflora (Raf.) Eaton*

Convolvulaceae

Convolullus arvensis L.
" sepium L.
" spithamaeus L.
Cuscuta glomerata Choisy
" gronovii Willd.
" spp.
Ipomoea purpurea (L.) Roth.

Polemoniaceae

Phlox bifida Beck.
" divaricata L.
" glaberrima L.
" pilosa L.
Collomia linearis Nutt.
Polemoniam reptans L.

Hydrophyllaceae

Hydrophyllum appendiculatum Michx.
" virginianum L.
Ellisia nyctelea L.

Boraginaceae

Cynoglossum officinale L.
Lappula echinata Gilib.
" virginiana (L.) Greene

Mertensia virginica (L.) Link
Myosotis arvensis (L.) Hill
" scorpioides L.
" verna Nutt.
Lithospermum angustifolium Michx.
" arvense L.
" canescens (Michx.) Lehm.
" croceum Fern.
" latifolium Michx.
Onosmodium hispidissimum Mack.
" occidentale Mack.

Verbenaceae

Verbena bracteata Lag. & Rodr.
" hastata L.
" simplex Lehm.
" stricta Vent.
" urticaefolia L.
Phyla lanceolata (Michx.) Greene

Labiatae

Teucrium canadense L.
" occidentale Gray
Isanthus brachiatus (L.) BSP.
Scutellaria ambigua Nutt.
" epilobiifolia Hamilt.
" lateriflora L.
" ovata Hill
" parvula Michx.
Marrubium vulgare L.
Agastache nepetoides (L.) Ktze.
" scrophulariaefolia (Willd.) Ktze.
Nepeta cataria L.
Physotegia speciosa Sweet
Physostegia virginiana (L.) Benth.
Glecoma hederacea L.
Prunella vulgaris L.
Leonurus cardiaca L.
Stachys arenicola Britt.
" aspera Michx.
" cordata Ridd.
" germanica L.
" homotrichia (Fern.) Rydb.
" tenuifolia Willd.
Salvia reflexa Hornem.
Blephilia ciliata (L.) Raf.
" hirsuta (Pursh) Torr.
Monarda fistulosa L.
" fistulosa f. alba
" punctata L.
Hedeoma hispida Pursh
" pulegioides (L.) Pers.
Pycnanthemum flexuosum (Walt.) BSP.
" pilosum Nutt.
" virginianum (L.) D. & J.
Lycopus americanus Muhl.
" rubellus Moench.
" uniflorus Michx.
" virginicus L.
Mentha canadensis L.
" citrata Ehrh.
" gentilis L. Glabrior (Hook) Rydb.
" piperita L.
" spicata L.

Solanaceae

Solanum carolinense L.
" dulcamara L.
Solanum nigrum L.
" rostratum Dunal
Physalis heterophylla Nees.
" lanceolata Michx.
" pubescens L.
" subglabrata M. & B.
" virginiana Mill.
Lycium halimifolia Mill.
Datura stramonium L.

Scrophulariaceaeae

Verbascum blattaria L.
" thapsus L.
Chelone glabra L.
Penstemon hirsutus (L.) Willd.
" digitalis Nutt.
" pallidus Small
Collinsia verna Nutt.
Scrophularia lanceolata Pursh
" marilandica L.
Linaria canadensis (L.) Dum.-Cours.
" minor (L.) Desf.
" vulgaris Mill.
Lindernia dubia (L.) Pennell
Gratiola neglecta Torr.
Leucospora multifida (Michx.) Nutt.
Mimulus ringens L.
Veronicastrum virginicum (L.) Farw.
Veronica americana (Raf.) Schw.
" arvensis L.
" connata Raf.
" peregrina L.
" serpyllifolia L.
Synthyris bullii (Eaton) Hell.
Aureolaria flava (L.) Farw.
" grandiflora (Benth.) Pennell
" pedicularia (L.) Raf.
Gerardia asper Dougl.
" gattingeri Small
" purpurea L.
" tenuifolia Vahl.
Dasistoma macrophylla (Nutt.) Raf.
Castilleja coccinea (L.) Spreng.
" sessiflora Pursh
Pedicularis canadensis L.
" lanceolata Michx.

Lentibulariaceae

Utricularis vulgaris L.

Orobanchaceae

Orobanche uniflora L.

Phrymaceae

Phryma leptostachya L.

Acanthaceae

Dianthera americana L.
Ruellia ciliosa Pursh

Plantaginaceae

Plantago aristata Michx.
" lanceolata L.
" major L.*
" purshii R. & S.
" rugelii Dene.

Rubiaceae

Houstonia lanceolata (Poir.) Britt.
Cephalanthus occidentalis L.
Diodia teres Walt.

Mitchella repens L.
Galium aparine L.
" asprellum Michx.
" boreale L.
" circaezans Michx.
" concinnum T. & G.
" obtusum Bigel.
" tinctorium L.
" trifidum L.
" triflorum Michx.

Caprifoliaceae

Sambucus canadensis L.
" pubens Michx.
Viburnum acerifolium L.
" affine Bush.
" lentago L.
" prunifolium L.
" rafinesquianum Schult.
" trilobum Marsh.
Symphoricarpos occidentalis Hook.
" rivularis Suksd.
Lonicera dioica L.
" flava Sims.
" prolifera (Kirsch.) Rehd.
Diervilla lonicera Mill.
Triosteum aurantiacum Bickn.
" perfoliatum L.

Valerianaceae

Valeriana ciliata T. & G.

Cucubitaceae

Echinocystis lobata (Michx.) T. & G.
Cucurbita foetidissima HBK.
Sicyos angulatus L.

Campanulaceae

Campanula americana L.
" aparinoides Pursh.
" rotundifolium L.
" uliginosa Rydb.
Specularia perfoliata (L.) A. DC.

Lobeliaceae

Lobelia cardinalis L.
" inflata L.
" kalmii L.
" siphilitica L.
" spicata Lam.

Compositae

Iva ciliata Willd.
" xanthifolia Nutt.
Ambrosia coronopifolia T. & G.
" elatior L.
" trifida L.
Xanthium commune Britt.
Vernonia fasiculata Michx.
Eupatorium altissimum L.
" maculatum L.
" perfoliatum L.
" purpureum L.
" rugosum Houtt.
" serotinum Michx.
Kuhnia eupatorioides L.
Liatris aspera Michx.
" bebbiana Rydb.
" cylindracea Michx.
" spicata (L.) Willd.
Grindelia squarrosa (Pursh) Dunal
Solidago altissima L.
" canadensis L.
" glaberrima Martens
" hirtella (Greene) Bush
" juncea Ait
" latifolia L.
" media (Greene) Bush
" nemoralis Ait.
" riddellii Frank
" rigida L.
" serotina Ait.
" speciosa Nutt.
" ulmifolia Muhl.
" uliginosa Nutt.
Boltonia asteriodes (L.) L'Her.
Aster anomalus Engelm.
" azurus Lindl.
" cordifolius L.
" drummondii Lindl.
" dumosus L.
" ericoides L.
" junceus Ait.
" laevis L.
" lateriflorus (L.) Britt.
" linariifolius L.
" novae-angliae L.
" oblongifolius Nutt.
" paniculatus Lam.
" pilosus Willd.
" prealtus Poir.
" prenanthoides Muhl.
" ptarmicoides (Nees.) T. & G.
" sagittifolius Wed.
" sericeus Vent.
" shortii Lindl.
" umbellatus Mill.
" vimineus Lam.*
Erigeron annuus (L.) Pers.
" canadensis L.
" divaricatus Michx.*
" philadelphicus L.
" pulchellus Michx.
" strigosus Muhl.
Antennaria fallax Greene
" neglecta Greene
" neodioica Greene
" plantaginifolia Hook.
Gnaphalium obusifolium L.
Polymnia canadensis L.
Silphium integrifolium Michx.
" laciniatum L.
" perfoliatum L.
" terebinthinaceum Jacq.
Parthenium integrifolium L.
Heliopsis helianthoides (L.) Sweet
Rudbeckia hirta L.
" laciniata L.
" subtomentosa Pursh
" triloba L.
Brauneria pallida (Nutt.) Britt.
" purpurea (DC.) Britt.
Ratibida pinnata (Raf.) Blake
" columnifera (Nutt.) W. & S.
Galinsoga ciliata (Raf.) Blake

Helianthus annuus L.
" decapetalus L.
" divaricatus L.
" giganteus L.
" grosseserratus Martens
" hirsutus Raf. L Mollis Lam.
" occidentalis Riddell
" petiolaris Nutt.
" rigidus (Cass.) Desf.
" strumosus L.
" tuberosus L.
Coreopsis lanceolata L.
" palmata Nutt.
Bidens aristosa (Michx.) Britt.
" comosa (Gray) Wieg.
" connata Muhl.
" coronata (L.) Britt.
" frondosa L.
" laevis (L.) BSP.
Helenium autumnale L.
Achillea millefolium L.
Chrysanthemum leucanthemum L.
Anthemis cotula L.
" tinctoria L.
Tanacetum vulgare L.
Artemisia annua L.
" biennis Willd.
" caudata Michx.
" dracunculoides Pursh
" gnaphaloides Nutt.
" serrata Nutt.
Cacalia atriplicifolia L.
" muhlenbergii (Sch-Bip.) Fern.
" suaveolens L.
" tuberosa Nutt.
Erechtites hieracifolia (L.) Raf.
Senecio arueus L.
" pauperculus Michx.
" plattensis Nutt.
Arctium minus (Hill) Bern.
Cirsium altissimum (L.) Spreng.
" arvense (L.) Scop.
" dicolor (Muhl.) Spreng.
" hillii (Canby) Fern.
" muticum Michx.
" vulgare (Savi) Airy-Shaw
Centaurea cyanus L.
" maculosa Lam.
" nigra L.
Tragopogon pratensis L.
Krigia biflora (Walt.) Blake
" virginica (L.) Willd.
Cichorium intybus L.
Lactuca canadensis L.
" biennis (Moench) Fern.
" floridana (L.) Gaertn.
" pulchella (Pursh) DC.
" sagittifolia Ell.
" scariola L.
Sonchus arvensis L.
" asper (L.) Hill
" oleraceus L.
Prenanthes alba L.
" altissima L.
" aspera Michx.
" cripidinea Michx.
" racemosa Michx.
Hieracium aurantiacum L.*
" canadense Michx.
" gronovii L.
" longipilum Torr.
" scabrum Michx.
Agoseris cuspidata (Pursh) D. Dietr.
Taraxacum vulgare (Lam.) Schrank
" laevigatum (Willd.) DC.

REFERENCES

(1) Bebb, Michael S. 1860—The flora of Ogle and Winnebago Counties. Prairie Farmer 22: 182-183.
(2) Bretz, J Harlen. 1923—Geology and mineral resources of the Kings quadrangle: Illinois Geol. Survey Bul. 43 (C): 205-304.
(3) Fernald, Evelyn I. 1935—A preliminary report of a study of the plants of Winnebago County, Illinois: Trans. Ill. Acad. Sci. 28 (2): 89, (1936).
(4) ———. 1940—Preliminary check list of herbaceous plants of Winnebago County, Illinois. Rockford College (mimeo.). 45 pp.
(5) Gleason, H. A. 1910. The vegetation of the inland sand deposits of Illinois: Illinois Sta. Lab. Nat. Hist. Bul. 9 (3): 23-174.
(6) Hopkins, Cyril G., et al. 1916. Winnebago County soils: Ill. Agr. Exp. Sta. Soil Rept. 12. 76 pp.
(7) Jones, G. Neville. 1945—Flora of Illinois: Amer. Midl. Nat. Monog. No. 2. 1-317.
(8) Nature Study of Rockford. 1914. The trees of Rockford and vicinity. 11 pp.
(9) ———. 1916. Shrubs and vines of Rockford and vicinity. 23 pp.
(10) Rolfe, Deette. 1929—The Rock River country of northern Illinois: Illinois Geol. Survey Educ. Ser. 2. 59 pp.
(11) Salisbury, Rollin D. and Harlin H. Barrows. 1918. The environment of Camp Grant: Illinois Geol. Survey Bul. 39. 75 pp.

CHEMISTRY

PLACE OF SCIENCE IN GENERAL EDUCATION

SISTER MARY MARGUERITE CHRISTINE, B.V.M.
Mundelein College, Chicago

The emergence of the United States as a leading world power and the obvious lack of preparation on the part of our citizens and leaders for their widened responsibilities has resulted in the realization of a need for a common grasp and a common over-view in the handling of facts and ideas in many discrete and isolated fields of knowledge. This great need has been met by educators through general education. The term has many and vigorous antagonists, especially in the science field, mainly because of a misconception and a misunderstanding of its fundamental meaning. Defined very simply, general education is non-vocational; it is that education which is the antithesis of a specialized education. However, general education is really a philosophy of education, and consequently has shades of meaning and application that are not so simply defined. In the East, the problem has been studied as "integrated" education, a term probably more readily acceptable to faculty members. There, general education is considered as only one phase of the broader integrated education because general education is concerned with giving all students, regardless of the later area of specialization, a basic understanding of the sciences, social sciences, and the humanities, culminating in integrated knowledge.

Whether we call it general or integrated education, the educators in the scientific world have been challenged: first, to devise suitable means of educating the layman, enabling him to have a better knowledge of science, a better understanding of its philosophy and methods, and a deeper appreciation of its potentialities and its limitations; second, to supplement the efforts of the social scientists and the teachers in the humanities in the attainment of the common goals of integrated understanding and appreciation. Whether or not this challenge be recognized or accepted depends on the open-mindedness and honesty of the scientists, and the rigorous, ruthless, and patient intellectual grasp of the many difficulties contingent on that challenge. During the past several years many scientists have expressed their opinions on this educational problem. Dr. Anton Carlson of the University of Chicago stated:

> **If it be true that an understanding of the scientific method and the fundamentals of the nature of man and the nature of the universe already achieved by the natural sciences is significant in a liberal college education, it would seem timely that we of the college faculties study this problem again, for I am satisfied that our nondescript "science requirement" for graduation usually falls short of the above goal. Streamlining the natural sciences in the college in the direction of purely vocational and professional training will not bring that goal even within sight of the mine run**

of college students. . . . We of the faculties must re-evaluate and reconstruct our entire college curriculum in the directions of essentials and mastery, and not primarily in the direction of speed, technical trades and professions, no matter how strong the myopic drive in the latter direction may grow. If we could discover the essential core of liberal education, then mastery, rather than speed would seem to be the goal.[1]

Along the same line, Dr. James R. Kilian, Jr., the President of Massachusetts Institute of Technology, recently stated the need for a broader general education for science students:

Engineers, scientists, physicians and other professional men are often called upon to assume important positions of leadership in the community. Unless they are aware of the major issues of the world, they may find it difficult to give competent direction. . . . Colleges have a profound responsibility to develop men and women who are not only skilled technicians but alert, intelligent citizens.[2]

Dr. Kilian explained that the objective of MIT is to educate top-flight engineers, scientists, and architects who may become community leaders. When technical education is too narrow, it tends to restrict the development of leaders. He insists that professional schools everywhere place greater emphasis on the teaching of humanities. Twenty percent of the total curriculum of the scientist at MIT runs to humanities, and he believes that in the years to come there will be a substantial increase.

There has always appeared to be a dichotomous viewpoint on science. Some scientists have exaggerated the need and importance of their subject matter to such an extent that their schools are turning out brilliant physicists and chemists with little background in cultural education or a vital preparation for living in a world of immediate social and economic problems. They use the scientific method in their field unfailingly and blindly but seem to be incapable of making the transfer of training to their problems of life. As Professor Phillip Frank of Harvard stated in the *American Journal of Physics,*

The result of conventional science teaching has not been a critically minded type of scientist but just the opposite. . . . This failure prevents the science graduate from playing in our cultural and public life the great part that is assigned to him by the ever mounting technical importance of science to human society.[3]

To such scientists, science is the *end-all* of education.

The other viewpoint on science teaching is that taken by many professors of the social sciences and the humanities, and by many scientific workers themselves. They look on science as a mere tool, a useful servant of humanity and forget that it is an integral part of human knowledge. They confound science with technology. Science aims at a systematic understanding of the world, while technology aims at the construction of consumers' goods on the basis of such theoretical understanding.

Fundamentally, the problem seems to be to influence all members of the faculty to appreciate the importance of each discipline and to so integrate the subject matter that the foundation of each liberal arts student be soundly based on all the broad areas of learning. The common criticism, as exemplified in the

[1] Carlson, Anton J., "The Offerings and Facilities in the Natural Sciences in the Liberal Arts Colleges," *North Central Association Quarterly,* XVIII, No. 2, (October, 1943), 154.

[2] Education in Review, *New York Times,* March 27, 1949.

[3] Frank, Phillip, *American Journal of Physics,* XV (1947), 202.

statements of the men quoted above, has often been that the scientist has over-loaded his curriculum to a much greater and more obvious extent than the social scientist and the student in humanities. However, just as educators will insist (and rightly) that a scientist is not liberally educated unless he has a good background in history and socio-economic problems, so, too, no one who is ignorant of science in nearly all of its aspects can be considered an educated person.

Dr. Van Evera of George Washington University recently discussed the position of chemistry in our present-day liberal arts education. He admits that the so-called liberal arts college no longer gives a liberal arts degree but rather a series of junior professional degrees and thus we do not truly have liberal education in the original sense of a hundred years ago, which was that education turned out men who used beautiful English naturally, who had a great breadth of knowledge, and who were quite practical in their approach to the problems of life. However, Dr. Van Evera states that the chemistry major's curriculum of today with its requirements in history, sociology, economics, and English, is nearly as broad and fundamental as was that of the liberal arts student a hundred years ago. And thus he claims that the science major is a far more broadly trained man than is his classmate who has almost no science. This statement depends, of course, on the requirements of each chemistry department for work in other fields versus the requirements in science for the non-science majors.[4]

[4] Van Evera, Benjamin D., "Chemistry and Liberal Education," *Chemical and Engineering News*, XXVI, No. 7 (February 16, 1948), 446.

Consequently, as a result of these divergent viewpoints on the present status of science in the liberal arts college, the two-pronged challenge thrown to the scientists must be accepted and studied. It is a problem that deserves immediate action, not one to be cast aside as the mere bickering of educationists.

The first challenge was to plan courses for an integrated general education program that will enable the non-science major to obtain a better knowledge of science, a better understanding of its philosophy and methods, and a deeper appreciation of its potentialities and its limitations. Does the system of elementary single-science courses given alike for majors and non-majors meet this demand? This question can be answered only in the light of the objectives of the course related to the general education of the student. Much discussion in regional work-shops and in national conferences has centered around this question, with the consequent development of basic general courses, scholarly in character but selective in content, involving the integration of several sciences and based on the purpose of acquisition of certain broad aims.

There is still a great deal of confusion surrounding the question of the proper content of a general course in science. A survey of what has been done along these lines has been edited by McGrath in *Science in General Education*.[5] Twenty-one representative colleges and universities have cooperated in the study and much valuable information is here available. No matter how many

[5] McGrath, Earl J., Editor, *Science in General Education*, Wm. C. Brown Co., Dubuque, Iowa, 1948.

and how varied the plans are that are studied the one criterion which is used in building a general course is: How much does the teacher have to give? Each general course is individual and unique in method of approach, selection of material, the organization of the material and emphasis. The only underlying common denominator is the end and objective of the general course, which is concisely stated in the fourth objective quoted by the President's Commission on Higher Education: To understand the common phenomena in one's physical environment, to apply habits of scientific thought to both personal and civic problems, and to appreciate the implications of scientific discoveries for human welfare.

Besides elementary science general courses, other science courses should be devised to be offered as electives to non-science majors, upper classmen, so they can broaden their general background in science. These should not be laboratory courses, for a non-science major will not elect a subject that will take a considerable amount of time. He is interested in fundamental knowledge, not in techniques. We science teachers often offer the observation that our majors must be generally educated since they frequently elect subjects outside their field in their junior and senior years, and that the non-science majors seldom, if ever, elect anything in science to balance their general education. Though this is true, the fault probably lies with us. We do not offer two and three hour courses in science with little or no prerequisites that any liberal arts student is invited to elect. Most of our science courses, if elementary, have long hours of laboratory work, and otherwise have heavy prerequisites.

Now to the second part of the challenge thrown to the scientists: along with the faculties in the other areas, they are to integrate subject matter into one whole, so that the student realizes his common goal of understanding and appreciation. This is a plea to cut across departmental lines in order to unify learning, to build not only vertically through the subject matter structure of the course but to spread horizontally, reaching out for implications in other and allied fields, linking together science with social science, with the humanities, with language, and with communications. General education courses are intended to impart a broad point of view, looking at the subject matter in its relation to the whole range of man's practical and intellectual interests and as part of the essential background against which the problems of contemporary civilization must find their solution. The suggestion has been offered that the general education of the science major be broadened by means of a course given in the senior year which would integrate related sciences and also show their relationship to non-science fields. Such a course, it is obvious, requires a generally educated teacher, and it is thus inevitable that the course reflect the mind and personality of the teacher far more than the traditional purely departmental courses. The success of any of these general courses, the rigorousness with which they are handled, and the strict regard given to the prin-

ciples of exact, systematic inquiry, depend primarily and solely on the teacher. There is no reason, except in the individual teacher, why any general course should be accused of dragging down academic standards by being a "watered-down" course.

The many difficulties and advantages of such courses need to be analyzed by individual institutions in the light of the needs of their students, the qualities of their faculties, and the purposes or objectives of their curricula. Only in this way will the challenge which the modern world has thrown to education be met.

GEOGRAPHY

OCCUPANCE OF THE MISSISSIPPI BORDER OF SOUTHERN ILLINOIS

JOHN H. GARLAND
University of Illinois, Urbana

The Terrain

About six miles below the Kaskaskie cutoff the Mississippi River abruptly swings from the left to the right side of its steep walled valley trough, and there it remains for the next fifty miles of its course. At this point the river is deflected sharply to the right to form the Cape Girardeau bend, below which it traverses a narrow six-mile channel through the hills to enter the broad alluvial plain below. This portion of the valley trough is the lower southern segment of the Mississippi border, one of the geographic sections of the southern district of Southern Illinois.

Physiographically, the southern district of Illinois is essentially that portion of the state south of the glacial boundary where the Ozark Plateau, the Interior Low Plateau, and the Coastal Plain provinces center. Geographically, the Mississippi border is a valley trough conspicuously incised in the eastern margin of the Salem Plateau. The Fountain Bluff bend is the only part of the trough eroded in the Shawnee Hills. The valley trough, which is here about six miles wide, describes a broad flat arc to the east. Since the river follows the right wall of the valley, which is the inside of the arc, the left or Illinois side of the valley is a broad alluvial bottom with a fall of about 0.4 foot per mile. Steep sided valley walls rising to a maximum of about 350 feet above the alluvial floor sharply delimit the segment.

The river itself, which varies in width from half a mile to 1¼ miles, is about 20 feet below the alluvial floor except at flood stage. Damaging floods occur in this segment of the valley about every seven years. The highest portion of the valley floor is the natural levee along the river upon which artificial levees have been constructed to protect the bottom lands from all but the most severe floods. From the natural levee the wide alluvial valley floor slopes gently toward the valley wall, forming swamps and poorly drained forested depressions adjacent to the steep valley wall. Drainage ditches have been constructed in an attempt to reclaim the poorly drained alluvial land for agriculture. Big Muddy River, the only tributary of any significance, enters the valley trough from the northeast, and pursues a meandering course through the lowland along the left valley wall for about 15 miles before entering the Mississippi through the Grand Tower chute. Although this is the widest part of the entire segment, Fountain Bluff, a forest covered remnant of the Shaw-

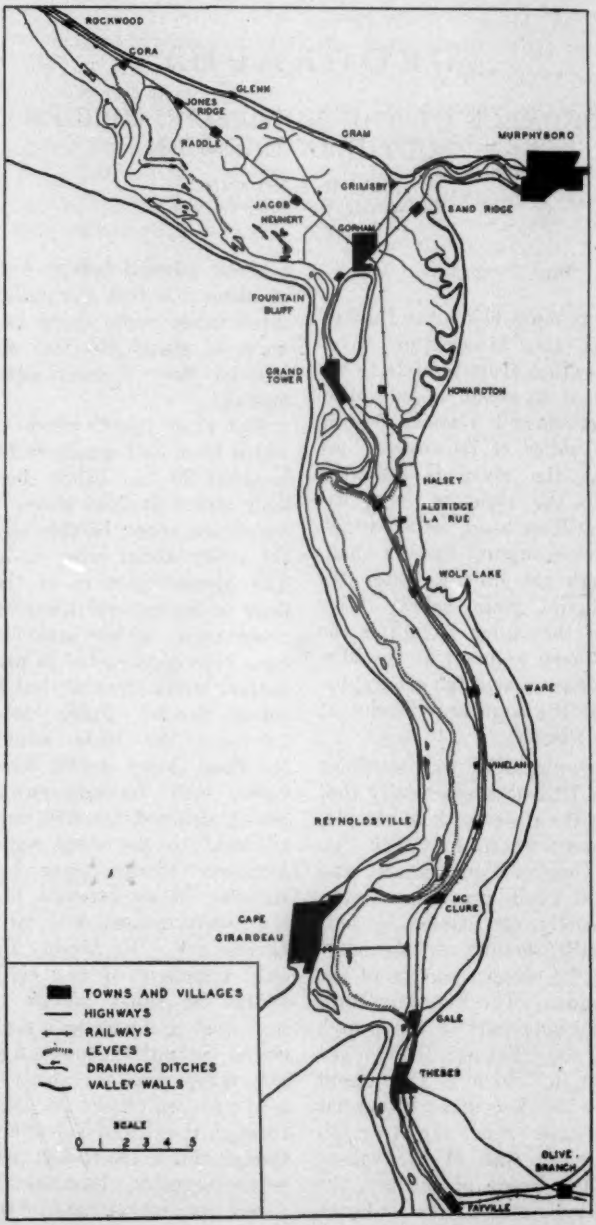

ROCKWOOD
CORA
GLENN
JONES RIDGE
RADDLE
GRAM
MURPHYSBORO
GRIMSBY
SAND RIDGE
JACOB
NEUNERT
GORHAM
FOUNTAIN BLUFF
GRAND TOWER
HOWARDTON
HALSEY
ALGERIDGE
LA RUE
WOLF LAKE
WARE
VINELAND
REYNOLDSVILLE
MC CLURE
CAPE GIRARDEAU
GALE
THEBES
OLIVE BRANCH
FAYVILLE
TOWNS AND VILLAGES
HIGHWAYS
RAILWAYS
LEVEES
DRAINAGE DITCHES
VALLEY WALLS
SCALE
0 1 2 3 4 5

FIG. 1

nee Hills three miles long and 1½ miles wide, rises above the alluvial floor at the river's edge (fig. 1). Although physically similar throughout, Big Muddy River conveniently divides the segment at the point where it crosses the valley bottom. Above are the Fountain Bluff and Oakwood bottoms, whereas below the Big Muddy are the Union bottoms, Cape Girardeau bend, and the Thebes narrows.

Cultural Patterns

Although corridor-like in its physical qualities, this segment of the Mississippi border is primarily a commercial agrarian ribbon penetrating a subsistence hills land, and is secondarily a corridor.

Corridor Qualities

The corridor qualities of the southern segment of the Mississippi border are best exemplified by the nature of the several patterns of transportation that occupy the valley trough. Water, rail, and highway routes parallel one another up and down the valley essentially from East St. Louis to Cairo. Barge transportation of bulky non-perishable freight on the river is undoubtedly the outstanding corridor quality since it is a portion of a major national route. Water transportation is of no major significance to the segment itself, although there are numerous landings along the waterfront. The railroads and the highways are better prepared to serve the agrarian valley floor.

Of the several railroads that serve the valley only one, the Missouri Pacific, traverses the entire segment on its way from East St. Louis to Cairo. From one end of the other this railroad right-of-way occupies a well-graded mid-position on the wide valley bottom. The Illinois Central and a branch of the Missouri Pacific enter the valley trough through the valley of the Big Muddy (fig. 1). The Missouri Pacific joins directly with the valley route whereas the Illinois Central crosses the valley floor to the waterfront, traversing the narrow terrace between Fountain Bluff and the river through Grand Tower where the rail pattern makes contact with river navigation. Below the Big Muddy River the Illinois Central parallels the Missouri Pacific railroad down the center of the valley bottom to the narrows. There the Illinois Central follows the waterfront, whereas the Missouri Pacific describes two arcs through the hills, one above and one below Thebes, where they join in a Y and cross the Mississippi on the only railroad bridge in the entire segment. For the last three miles the Missouri Pacific follows the waterfront as does the Chicago and Eastern Illinois which comes in over the Illinois Central tracks from the south to make contact with the waterfront.

The major highways form a similar pattern, making use of the same physical feature. The major highway, State Route 3 from Cairo to East St. Louis, traverses the entire segment. South of the Big Muddy River the highway and the two railroads follow the same route up the center of the alluvial valley floor. North of the Big Muddy where the railroads separate, the highway continues on a straight course up the valley along the eastern edge of Fountain Bluff directly to the valley

wall which it follows for the rest of the distance. State Route 146 from Cape Girardeau, Missouri, to Murphysboro crosses the Mississippi on a toll bridge and joins State Route 3 which it follows to the mouth of the Big Muddy valley where it leaves the valley. Innumerable short unimproved roads, chiefly levee and trans-valley routes, complete the pattern of transportation.

Settlements

Within the segment are 20 towns and villages which vary in population from ten to 1,043. With the exception of two small villages all are on the railroad, indicating the commercial nature of the valley bottom agriculture. There are several railroad stations not connected with villages. Only four of the towns and villages are incorporated. Grand Tower with a population of 1,043 is the largest and Rockwood with only 246 is the smallest. Thebes, population 730 and the second largest town, like Grand Tower is a railroad town on the waterfront. Unlike Grand Tower, Thebes occupies the hills on the narrows at the lower end of the segment. Gorham, population 595, is a railroad junction. McClure, population 450, is the largest unincorporated village. The other fifteen villages are mere hamlets consisting only of the necessary function of a commercial agrarian area. Only three of this group have a population of 100 and more, and the largest, Gale, is only 200. Nine of the twenty towns and villages have post offices and only two, Grand Tower and Gorham, have banking facilities. One little hamlet, Neunert, with a population of 31, occupies a site on the valley floor untouched by railroad, hardsurfaced highway, or river transportation.

Agrarian Patterns

As the little market towns arranged at regular intervals along the railroads attest, commercial grain farming is the dominant economy of this segment of the Mississippi border. The deep alluvial soil of the valley floor is the basic natural environmental item upon which this type of productive occupance is based. Recent alluvium and the prairie soils of the recent Wisconsin drift are the only types of areas in Illinois capable of withstanding the drain of continuous commercial grain cropping. Thus the entire segment is one continuous ribbon of commercial grain farming, varying from place to place only in intensity and arrangement of details. Corn rotated with winter wheat constitute the basis of production, with alfalfa and other hay crops to feed the small livestock population a low second. Hogs are the most important animals although a few cows and work animals are kept on each farm. Although most of the farms are mechanized, heavy machinery is not used to the best advantage on poorly drained land. Especially on the smaller farms mules furnish most of the motive power. Much of the valley floor is poorly drained despite drainage ditches, leaving large tracts of tree lined swamps on the lowest portions of the valley floor.

Valley Bottom Sectors

North of Big Muddy River, which conveniently bisects the valley segment at the place where it enters

the Mississippi, are two valley bottom sectors. From Rockwood to the Fountain Bluff bend, which lies directly across the valley bottom from the mouth of the Bid Muddy valley, is the Fountain Bluff bottom. This sector of the valley bottom is approximately sixteen miles long and about six miles wide. Although a levee, some places as far as a mile from the river, encloses the upper half of the sector behind which drainage ditches carry water to the river, large tracts are swamps and marshes.

Approximately half of the bottom land is cultivated. Winter wheat and corn constitute the major crops and are about equal in acreage. The production per acre of both crops is highest here of any place in the valley. The acreage of wheat is a little greater than that of corn. Hay crops and oats form a weak second to corn and wheat and are used as forage for the livestock since much of the grain is sold. Much of the soil is heavy clay which is difficult to cultivate under unfavorable moisture conditions and thus accounts for much unused arable land.

Five small market towns spaced at approximately three mile intervals line the railroad in the center of the valley bottom whereas several more line the highway at the foot of the valley wall. Neunert is the center of a German farming community between the railroad and the river. Gorham or Fordyce at the railroad junction is the largest town in the sector.

From the Fountain Bluff bend to the mouth of the Big Muddy is the Oakwood bottom, a sector about twelve miles long and six miles wide. Because of the position of Fountain Bluff on the waterfront and the relatively high natural levee along the remainder, protecting levees have not been built except to enclose the Big Muddy River on the south. Since settlement is limited to the wide natural levee, the low bottom to the east, through which the Big Muddy meanders and into which the drainage of the sector is ditched, is allowed to flood in periods of danger to cities down-stream. Much of the sector, including Fountain Bluff but excluding the southeastern natural levee, is within the limits of the Shawnee National Forest.

Although less agricultural than any other sector, commercial grain farming of corn and winter wheat predominates in the cultivated portions of the valley bottom. Unlike the Fountain Bluff bottom to the north where wheat was slightly greater in acreage than corn, corn acreage exceeds wheat by about one-third. This is in part due to late floods and the necessity of replanting.

Small market towns are conspicuously absent. Grand Tower, the largest town in the entire valley segment, is an old river-town through which a railroad passes although the highway by-passes it about a mile to the east.

South of the Big Muddy River is the Union Bottom sector which extends for about eighteen miles down the valley where it joins the Cape Girardeau bend, the inside of a sharp four mile bend of the Mississippi. The entire area is enclosed by a levee from the valley bluff south of the Big Muddy to the valley bluff below the Cape Girardeau bend. Almost the entire sector is drained into

a main ditch which parallels the left valley wall on the lowest part of the valley bottom and enters the Mississippi through a small tributary stream at the point where the river approaches the left bluff below the Cape Girardeau bend.

Commercial grain farming dominates the flat alluvial land. Unfenced fields of corn and winter wheat with small areas of hay are characteristic. Hogs are the most important livestock. Small market villages spaced at about three mile intervals line the railroad and the highway which in this sector of the valley traverse the middle of the valley floor.

South of the Cape Girardeau bend the river enters the Thebes narrows, a valley less than three quarters of a mile wide which extends for about six miles through the hills to the broad embayment below. The railroads and highway from the wide alluvial bottom concentrate in the narrow valley, and at Thebes a high level railroad crossing is made at the narrowest point in the valley.

These are the essentials of the occupance of a segment of the Mississippi border. The homogeneous valley trough is the basis upon which the occupance is organized. Problems arising from unwise associations of cultural and natural environmental conditions are varied and conflicting. Commercial grain farming is the major association with the recent alluvial soil, but it has its attendant problems of drainage and flooding. The transportation factors are associated with the well graded and orientated corridor. These are local or at best interregional considerations. Flood control and other problems related directly to the river are intraregional in nature, the solution of which has very far-reaching ramifications.

Thus the southern segment of the Mississippi border is essentially a fifty mile ribbon of commercial grain farming as well as a corridor of secondary consideration associated with a wide alluvial valley bottom which is projected through the hills land of the southern district of Illinois.

THE PULP AND PAPER INDUSTRY OF THE LAKE STATES

L. MARJORIE SMITH
Northwestern University, Evanston

Four regions of the United States are outstanding in the production of paper: (1) the Northeast; (2) the Pacific Northwest; (3) the South; and (4) the Lake States. Paper making in the first of the regions, the Northeast, dates back to 1690.[1] For more than a century the Northeast held a virtual monopoly on American paper manufacturing. Three important factors influenced the location of the industry during that early period: (1) cheap power; (2) a large volume of clear and pure process water; and (3) proximity to large centers of population.[2] The migration of the paper industry into the other three regions had to await economic developments in those regions and technological developments in the industry.

In the Lake States[3] the earliest beginnings of the paper industry appeared around 1800. Development in this region was assisted by four forces: (1) construction of canals and steam railroads; (2) adoption of steam power; (3) demand created by the Civil War; and (4) technological advancement in the industry.

Construction of canals and steam railroads accelerated the growth of population in the region. In addition, better connections with the large population centers in the Northeast and with sources of raw materials were provided. Adoption of steam power broke the industry's dependence on water power sites. The Civil War created a shortage of paper and raw materials. This condition stimulated an interest in raw materials other than rags. These raw materials,[4] some of which are abundant in the Lake States, were provided through chemical technological advancements in the industry.

An analysis of the present-day industry in the Lake States demands consideration of several facets. Among these, the distribution of manufacturing plants in the industry and the technology employed in the manufacture of the product are of prime importance. To a geographer, however, the chief interest lies in an explanation of the factors influencing the location of the component plants.

[1] "William Bradford, a printer, was one of the founders of the first paper mill in the British North American Colonies. In 1690 he, with William Rittenhouse and two others, started the first Rittenhouse mill on Wissahickon Creek in Germantown, Pa." (L. T. Stevenson, *The Background and Economics of American Papermaking*, [New York and London: Harper & Brothers Publishers, 1940] p. 7.)

[2] Cities furnished the raw material, rags, and supplied a market for the finished paper.

[3] For the purpose of this paper the Lakes States are considered to include those states west of the Appalachian Plateau which border the Great Lakes. The region includes Ohio, Indiana, Illinois, Michigan, Wisconsin, and Minnesota.

[4] Straw, wood hemp, jute, and cotton hull fiber.

TABLE 1.—STATISTICAL COMPARISON OF SELECTED MILLS

Mill	Location	Yearly Production of Paper in Tons	Daily Consumption of Water in Gallons	Source of Water	Yearly Consumption of Coal in Tons	Source of Coal	Power Used Per Year
1.	Manistique, Michigan	25,000	1,000,000		25,000	W. Va.	
2.	Green Bay, Wisconsin	40,500	33,000,000	Fox R. East R.	70,000	W. Va.	10,000 K.W.H. of electicity
3.	Appleton, Wisconsin	15,000	6,000,000	Fox R.		W. Va.	2500 Water H.P. 2500 H.P. steam turbine
4.	Cloquet, Minnesota	96,000	37,000,000	St. Louis R.	85,000	W. Va. Pa.	96,342,750 K.W.H. electricity
5.	Detroit, Michigan	30,000	20,000,000	River Rouge	60,000	W. Va.	1,200,000,000 lbs. of steam and 30,000,000 KWH electricity
6.	Kalamazoo, Michigan	75,000	8,000,000	KalamazooR.	110,000	W. Va. Ky.	
7.	Escanaba, Michigan	50,000		Escanaba R.	70,000	W. Va.	
8.	Indianapolis, Indiana	20,000		White R. City Water			
9.	Chicago, Illinois	3,500			8,000		3,000,000 K.W.H. electricity
10.	Wausau, Wisconsin	25,000		Wisconsin R. Wells	20,000	Ohio Pa.	20,000,000 K.W.H. electricity

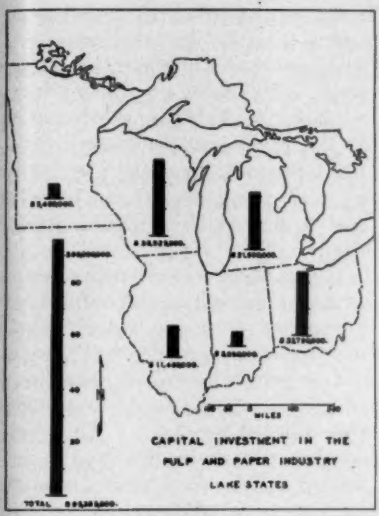


FIG. 1.

FIG. 2.

SCOPE OF INDUSTRY

Capital Investment.—The capital investment in the pulp and paper industry of the Lake States totals almost one hundred million dollars (fig.1).[5] The three states of Wisconsin, Ohio, and Michigan account for more than three-fourths of the total investment.[6] Of the remaining fourth, Illinois provided an investment exceeding that of Minnesota and Indiana combined.

Distribution of Plants.—Pulp mills are concentrated in two widely separated areas: Northern Wisconsin and Southwestern Ohio (fig. 2). Northern Wisconsin, the larger area, has numerous mills along the Fox and upper Wisconsin rivers. Three mills in Upper Michigan and four in Minnesota are on the periphery of the Wisconsin area. Southwestern Ohio, the smaller area, has its pulp mills concentrated in the Miami Valley. Isolated mills exist at Chicago and Detroit.

The paper mills are concentrated within a rectangle which is 250 miles wide and runs on a northwest-southeast axis from central Minnesota through Ohio (fig. 3). Only eight paper mills lie outside this rectangle. The pattern is characterized by marked nucleation and linear dispersion. Four nuclei are in: (1) the Fox River Valley; (2) the Kalamazoo River Valley; (3) Chicago; and (4) the Miami River Valley. Dispersed lines are coincident with three river valleys: (1) the Upper Mississippi; (2) the Upper Wisconsin; and (3) the Middle Scioto. In addition, isolated plants are located in other river valleys and in areas served by cheap transportation.

[5] Statistics were compiled from the *Thomas Register of American Manufactures*—Seventh Edition, Vol. II, 1947.

[6] Wisconsin, 29.5 per cent; Ohio, 24.8 per cent; Michigan, 22.5 per cent; Illinois, 12.0 per cent; Minnesota, 5.6 per cent; and Indiana, 5.2 per cent.

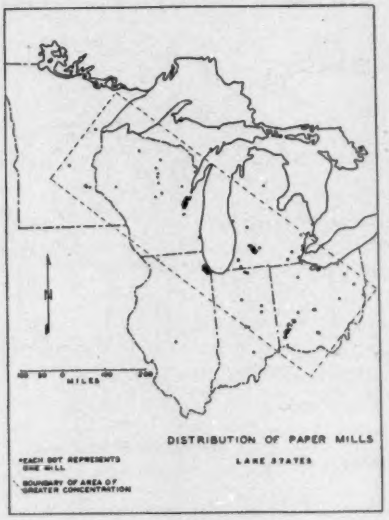


FIG. 3.

PRODUCTION PRACTICES

Use of Water.—The marked concentration of pulp mills and paper mills in river valleys reflects the heavy dependence upon the basic resource of water (Table 1). This resource plays a major role in pulp and paper production.[7] In one pulping process[8] water is played on huge grindstones to prevent burning. Large quantities of water are employed in other processes which employ chemicals.[9] In addition, water is used as the chief means of transport for carrying pulp to various stations throughout the plant. Power[10] to run the plant depends upon water, whether it is steam, hydro-electric, or thermo-electric. The importance of water, in another sense, is its use as a means of transportation for bringing raw materials to the plant and for carrying finished products from the plant. It is especially important for bringing coal to many of the manufacturing sites.

Use of Power.—Perhaps power occupies the position of importance secondary only to water in the manufacture of paper. Giant machines driven by thousands of units of power are necessary to produce the finished product. Mills commonly have their own power producing units. Power used may be one or more of four types: (1) water; (2) hydro-electric; (3) steam; or (4) thermo-electric. The latter two of these types depend upon the use of coal.

Use of Coal.—Mills annually use many thousand tons of coal per year (Table 1). West Virginia supplies most of the coal for the pulp and paper mills in the Lake States. The Great Lakes offer a cheap means of transportation which is utilized by many mills. Cheaper rates of transportation for these mills give them an advantage over mills which depend upon rail transportation for their coal supplies.

Raw Materials.—Wood pulp[11] constitutes most of the matrix purchased or manufactured for paper

[7] In a Cloquet, Minnesota, mill selected for this study, 87,000,000 gallons of water per day are used in a yearly production of 96,000 tons of paper. A Green Bay, Wisconsin, plant employs 33,000,000 gallons per day to manufacture 40,500 tons annually.

[8] Paper is chiefly cellulose in some form. Cellulose is the chief constituent of the solid framework of all leafy green plants. Pulping processes, although numerous and diverse, are all concerned with changing the cellulose of plants to paper. (Stevenson, *op. cit.*, p. 16.)

[9] Chemicals dissolve out all materials in the wood except cellulose. After the cellulose has been extracted it is washed to remove the cooking liquor.

[10] Early sites made use of water power.

[11] A notable exception is an Appleton, Wisconsin, plant which was selected for this study. This plant manufactures fine personal and business writing paper from cotton fibre pulp. The pulp is made of cotton cuttings from garment factories and of cotton linters. The cotton cuttings come from distributors in Chicago, New York, Rochester, and St. Louis. Cotton linters come from 450 cotton seed oil mills located throughout the south.

making in the Lake States. Sources of supply for mills which purchase their wood pulp are: (1) Canada; (2) Scandinavia; (3) New England; (4) the Pacific Northwest; and (5) the Lake States. The mills which manufacture pulp utilize several woods[12] from Canada, Wisconsin, Minnesota, and the Upper Peninsula of Michigan. The supply in these areas, however, is not great. This condition, if not corrected by conservation measures, offers the only threat to continued advancement of the industry.[13]

Eleven minor materials are included in the manufacture of pulp and paper. The chemical pulping processes employ lime and limestone, alum, sulphur, soda ash, salt cake, chlorine, and sulphate aluminum (Table 2). Filler of clay and starch and rosin size add body and finish to the paper. Some mills also make use of dyes.

Transportation. — Three methods of transportation serve the mills: (1) rail; (2) water; and (3) truck. Finished products, representing a great diversification of types of paper and paper board, go to all parts of the United States and foreign countries.[14] The greatest amounts, however, are destined for cities in the Lake States region. Large total population in the region provides a ready market for much of the production.

Table 2.—Source of Minor Raw Materials

Lime and limestone	Michigan Wisconsin Illinois
Sulphur	Texas
Soda ash	Ohio
Salt cake	Montana Canada
Chlorine	New York Michigan
Alum	Missouri
Rosin size	Wisconsin Alabama
Clay	Georgia
Starch	Illinois Iowa
Sulphate aluminum	Wisconsin
Dyes	Delaware

Factors Influencing Location of Mills

The foregoing analysis of technology employed in the production of pulp and paper demonstrates the factors which influence the location of mills. As in the early days of the industry, these locational factors primarily are: (1) a large volume of clear and pure water; (2) cheap power; (3) proximity to sources of the chief raw material; and (4)

[12] Spruce, balsam, poplar, aspen, jack pine, birch, tamarack, and hemlock.

[13] "The pulp and paper industry in the Lake State (the Lake States here include only Michigan, Wisconsin, and Minnesota) is not self-sufficient in local sources of raw materials. In recent years the region has imported about one-fourth of the pulp wood it consumes—mostly spruce and balsam from Canada. Scandinavian countries contributed a small part of the region's wood pulp needs prior to the late war and have resumed shipments on a limited basis. . . . The only new pulpwood logging areas of substantial size in the Lake States are in northern Minnesota, particularly within the boundaries of state and national forests. Seventy per cent of the Lake States' remaining supply of jack pine is in Minnesota and 33% is within the boundaries of the Superior National Forest. . . . The pulp and paper industry in the Lake States region is strategically located with regard to local and national markets. If sufficient attention is given to the problem of providing raw material, the industry can be maintained indefinitely and may even expand. However, there must be a change of attitude on the part of the industry toward the use of raw materials. The forest must be treated as a renewable resource rather than as a mine. Also, pulp wood operations must be integrated with those of other forest users.

"The 50 million acres of commercial forest land in the Lake States can meet the requirements of accessibility, productivity, and cheapness to reproduce if handled under proper management. More rapid forest growth rates in the South and West are offset by higher freight charges to national markets. Under normal conditions of competition, the pulp and paper industry of the Lake States has as good, if not better, opportunities for permanent and sustained production as those of any other region." (*Pulpwood Stands, Procurement, and Utilization* [New York: Technical Association of the Pulp and Paper Industry, 1947] pp. 40, 43, and 51.)

[14] Newsprint production has declined in the area. The high cost and increased scarcity of spruce has eliminated this product from the region. (Ibid., 40.)

proximity to markets. Transportation facilities must be added to this list. Availability of unskilled labor is also an important consideration in the location of present-day mills.

The Lake States area contains many sites which provide the chief factors influencing location of pulp and paper mills. At these sites mills have started, multiplied, and developed to proportions which place this region among the four outstanding in the country in the production of pulp and paper. The Lake States region has a good chance for continued and sustained production. The only real hazard to the future of the industry in the Lake States region lies in the possible failure to provide for the replenishment of pulp wood.

BIBLIOGRAPHY

Books and Articles

STEVENSON, L. T., *The Background and Economics of American Papermaking.* New York and London: Harper and Brothers Publishers, 1940.

WRIGHT, ALFRED J., "The Industrial Geography of the Middle Miami Valley, Ohio," *Michigan Papers in Geography.* Vol. VI, 1936, pp. 401-427.

Pamphlets and Bulletins

The Story of News Print Paper. Published by the News Print Service Bureau. New York, 1936.

Pulpwood Stands, Procurement, and Utilization. Published by the Technical Association of the Pulp and Paper Industry. New York, 1947.

GEOLOGY

PRESENT STATE OF KNOWLEDGE REGARDING THE PRE-CAMBRIAN CRYSTALLINES OF ILLINOIS*

ROBERT M. GROGAN
State Geological Survey, Urbana

The oldest sedimentary strata of Illinois rest on a foundation of igneous and metamorphic rocks which are commonly referred to as the pre-Cambrian crystallines or basement complex. Rocks of corresponding age crop out in the nearby states of Wisconsin, Minnesota, Iowa, and Missouri, but in Illinois they are buried under a variable thickness of later sediments and can be examined only in cuttings or cores from deep wells.

Six wells in Illinois penetrate these crystalline rocks, one each in Boone and DeKalb counties, two in Lee County, and two in Pike County, figure 1. The four wells in the northern counties encountered granite, but the two southern wells encountered rhyolite porphyry and granophyre. From 3 to 639 feet of these ancient igneous rocks were cut in the various wells. All were drilled as oil tests and all but one, the Herndon Drilling Co.—Campbell well in Pike County, were drilled with cable tools.

Data regarding the names of the wells and their locations, the depth and sea-level elevation of the tops of the crystalline rocks, and their thickness and character are given in table 1. The greatest and least depths are 3845 and 2221 feet respectively. In terms of elevation, the highest occurrence is 1401 feet below sea-level and the lowest is 3046 feet below sea-level, a range of 1645 feet. As a measure of the local relief involved, the difference in elevation of the crystalline surface is 356 feet in the two Lee County wells which are five miles apart, and 1088 feet in the two Pike County wells which are 8½ miles apart.

FIG. 1.—Location of wells that penetrate pre-Cambrian crystalline rocks.

* Published with permission of the Chief, Illinois State Geological Survey.

TABLE 1.—PRE-CAMBRIAN CRYSTALLINE ROCKS IN ILLINOIS WELLS

Name of well	Location	Top of crystalline rocks		Thickness penetrated, feet	Type of rock encountered
		Depth in feet	Sea-level elevation		
1. Northern Illinois Oil and Gas Co. Taylor No. 1	28-43N-3E Boone County	2925	−2105	73	Gray granite
2. Paul Schulte, Wyman No. 1	35-41N-5E DeKalb County	3845	−2935	639	Red granite
3. H. O. Carr, Vedovell No. 1	35-20N-10E Lee County	3465	−2690	187*	Red granite and felsite
4. Amboy Oil and Gas Co., McElroy No. 1	30-20N-10E Lee County	3760	−3046	12	Red granite
5. Herndon Drilling Co., Campbell No. 1	15-4S-5W Pike County	3204	−2488	3	Red-brown rhyolite porphyry
6. Panhandle-Eastern, Mumford No. 1	21-5S-4W Pike County	2221	−1401	5	Red granophyre

* As of April 26, 1949; well reported shut down.

From the limited information provided by the six wells and the character of the topography of exposed and buried pre-Cambrian surfaces in nearby areas,[1] it is inferred that the buried pre-Cambrian terrain in Illinois probably ranges from a broadly undulatory surface studded with scattered residual hills to one featured at least in part by close-spaced hills and valleys, and that a local relief of as much as 1000 feet may be a common situation. Regional warping and local faulting and folding in post-Cambrian time have doubtless modified the original attitude of this terrain. It has been suggested that the crystalline surface becomes generally lower eastward from the Ozark dome region of Missouri and southward from Wisconsin until it reaches depths greater than 11,000 feet below sea-level in southeast Illinois.[2]

Study of cuttings shows that with the exception of altered felsite encountered in the H. O. Carr—Vedovell No. 1 well in Lee County, the crystalline rocks found in the four wells in the northern part of the State all are red or gray granites of medium to coarse-grained texture. The common essential minerals in-

[1] Buckley, E. R., Geology of the disseminated lead deposits of St. Francois and Washington Counties; Missouri Bur. Geology and Mines, Vol. 9, Part 1., pp. 17-18, 1909.
Weidman, Samuel, The geology of north central Wisconsin; Wisconsin Geol. and Nat. His. Survey, Bull. No. 16, pp. 385-395, 1907.

[2] Workman, L. E., and A. H. Bell, Deep drilling and deeper oil possibilities in Illinois; Illinois Geol. Survey Rept. Inv. 139, p. 2060 and figure 14. Reprinted from Bull. Am. Assn. Petroleum Geologists, Vol. 32, No. 11, 1948.

FIG. 2.—Sketch of microporphyritic felsite from dike in granite from H. O. Carr-Vedovell well, Lee County. Rectangular crystals represent altered feldspar; bundles of curving lines represent crystallites arranged in flowage pattern; black represents opaque minerals; and the rest is cryptocrystalline material. Magnification 120X.

clude quartz, orthoclase and microcline feldspar, and biotite. The common accessory minerals are apatite, zircon, rutile, magnetite, and ilmenite. Chlorite and epidote also occur in small amounts. Plagioclase feldspar is present in such small amounts as to be practically an accessory mineral; oligoclase and andesine are the varieties found. Hornblende is rare or lacking in all except the Northern Illinois Oil and Gas Co.—Taylor well in Boone County, in which it is abundant. The granite in the Taylor well also differs from the other granites in that it is grayer, contains abundant titanite, much of which is in large grains, and has andesine rather than oligoclase as its plagioclase feldspar. This difference in mineralogical character might result either from compositional variations within a single granite mass or from the presence of a separate and different body of granite at the Taylor well locality.

From a petrographer's point of view, the most interesting feature of these northern wells is the altered felsite found in the granite in the H. O. Carr—Vedovell well, which because of its much different textural character is presumed to occur as dikes intrusive into the granite. The well penetrated successively 95 feet of granite, 35 feet of altered felsite, 52 feet of granite, 7 feet of altered felsite, and finally 3 feet of granite. The least-altered particles of felsite recovered in the cuttings are reddish and purplish brown in color, and as seen in thin section, figure 2, are composed of numerous tiny square to rectangular crystals of altered feldspar in a matrix consisting of numerous crystallites and of cryptocrystalline material of indeterminate composition which may have been glass originally. The crystallites around many of the tiny feldspar crystals are arranged in a pattern suggestive of flowage while the mass was still partly fluid.

The felsite has been altered to a light green waxy clay, whose X-ray diffraction pattern is that of a mica-montmorillonite mixed layer mineral in which the proportion of mica to montmorillonite is about 5 to 1.[3] The progressive nature of this alteration, presumably by chemically active hot water which traversed fractures alongside or within the dikes, may be observed in the appearance of various fragments in the samples. It is reflected first in a change in color

[3] X-ray analysis by W. F. Bradley, Chemist and Head, X-ray Division, Illinois Geological Survey.

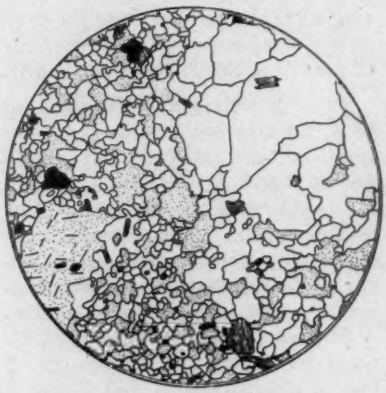


FIG. 3.—Sketch of rhyolite porphyry from Herndon Drilling Co.—Campbell well, Pike County. Clear grains are quartz, stippled are feldspar, black are mostly magnetite and pyrite, and grains with longitudinal lining are biotite and muscovite. Large areas of quartz appear as single grains in plain light. Magnification 48X.

FIG. 4.—Sketch of micropegmatitic texture in granophyre from Panhandle-Eastern-Mumford well, Pike County. Quartz (clear) is intergrown with feldspar (dashed line pattern). Black grains are magnetite. Magnification 33X.

from brownish to mottled shades of tan and greenish gray and a slight decrease in hardness, then by increasing dominance of the green color and further decrease in hardness until in the final stage the entire mass is changed to soft green clay. In thin section the original microporphyritic texture of the felsite is clearly preserved in the green clay, a further proof that the latter is an alteration product of the felsite. Additional evidence that this alteration was caused by hydrothermal solutions is afforded by the presence of small fluorite crystals in the upper part of the uppermost dike and in the 45 to 50 feet of granite overlying the dike, the somewhat altered appearance of the granite immediately above the uppermost dike, and the presence of moderately abundant pyrite in the green clay.

The crystalline rocks in the Pike County wells are distinct petrographically from the granites found in the northern wells. The rock from the Herndon Drilling Co.—Campbell well is a purplish-brown rhyolite porphyry and that from the Mumford well a granophyre. Both of these rocks are fine-grained members of the granite clan and both are types common in the pre-Cambrian exposures approximately 125 miles south in the St. Francis Mountain area of southeastern Missouri.[4]

The rhyolite porphyry in the Campbell well consists of large crystals of feldspar and quartz up to 7 millimeters long, comprising together about 20 percent of the rock, in a

[4] Erasmus Haworth, Crystalline rocks of Missouri: Missouri Geol. Survey, Bulletin 8, pp. 81-222, 1895.
Tarr, W. A., Intrusive relationship of the granite to the rhyolite (porphyry) of southeastern Missouri: Geol. Soc. America, Bull. 43, pp. 965-992, 1932.

fine-grained, equigranular, fresh-looking groundmass consisting of 60 percent quartz and 40 percent orthoclase feldspar, figure 3. Other minerals present include minor amounts of muscovite and biotite mica, chlorite, pyrite, magnetite, hematite, zircon, and garnet. The large feldspar crystals include microcline, orthoclase, and microperthite, and many of them have rectangular or partly rectangular outlines. The large quartz crystals are oval to lenticular in outline, and are made up of groups of interlocking smaller crystals. The edges of many of the large quartz grains are scalloped or embayed in the fashion commonly attributed to corrosion of early-formed crystals by the still-liquid portion of magma. Many of the large crystals have been fractured, either during flowage of the mass while partially liquid or as the result of later metamorphic shearing. The cracks in some of the crystals are filled with later quartz and in others by portions of the quartz-feldspar groundmass. Further evidence of flowage or shearing is faintly apparent in traces of banding caused by parallelism of the long axes of lenticular quartz grains and a slight color banding. In general, the equigranular mosaic texture of the groundmass and the completely random orientation of the micas suggest recrystallization as a result of metamorphism. The rock has been termed a recrystallized quartzite by some, but the large amount of feldspar in the groundmass and the general non-detrital appearance of both the individual crystals and the rock as a whole make this interpretation questionable.

The original character of the crystalline rock from the Panhandle-Eastern—Mumford well, the other Pike County occurrence, is more difficult to determine as the available samples consist entirely of fragments smaller than 1/8 inch. However, it is apparent that the rock is red in color and consists largely of quartz and the feldspars microcline and orthoclase. The very minor amount of accessory minerals includes magnetite, chlorite, zircon, fluorite, and pyrite. The overall texture is an uneven medium-grained mosaic of quartz and feldspar with a few larger rectangular microcline crystals which probably are phenocrysts. Thus the rock is probably a porphyry. The most conspicuous textural feature is the abundance of an intergrowth of quartz and feldspar in micropegmatitic fashion, figure 4. Porphyries of the type described are commonly termed granophyres and this name is therefore applied to the rock from the Mumford well.

In connection with the description of the crystalline rocks of Illinois, the Insane Asylum or City Sanitarium well in the city of St. Louis is of interest as it has been reported to have reached granite.[5] This well was drilled in 1869, at which time its depth of 3843½ feet, as originally reported, made it one of the deepest wells in the world. More recently the Missouri Geological Survey gives the total depth as 3883 feet[6] from which it is inferred that the well was deepened sometime in its history.

The original published log of the well reported that the last 40 feet

[5] Broadhead, G. C., On the well at the Insane Asylum, St. Louis County: Trans. Acad. of Sci. of St. Louis, Vol. 3, pp. 216-223, 1878. The occurrence of granite in this well is also mentioned in an anonymous note in American Jour. Sci. 3rd Series, Vol. 9, p. 61, 1875.

[6] Communication from Edward L. Clark, State Geologist, February 25, 1949.

drilled was hard red granite because cuttings contained grains of red quartz and feldspar[7] and this interpretation has been repeated in succeeding publications that made reference to the well. Lately the Missouri Geological Survey kindly supplied cuttings from the St. Louis well from depths of 3522 to 3848 to allow comparison of the reported granite with the granites in Illinois. Study of the samples indicates, however, that no granite or other crystalline rock was encountered, but that the material penetrated was entirely sandstone, in part feldspathic and shaly. Feldspar is present in the upper samples from 3522 to 3620, absent in the middle samples from 3620 to 3817, and increasingly abundant again in the lowermost samples. Mottled shale is present in various places. No mica was observed, nor any evidence that any of the quartz or feldspar grains came from the drilling of a quartzite or granitic rock. The most reasonable interpretation appears to be that the lower part of the St. Louis well to a depth of 3848 feet penetrated a thick sandstone section containing occasional feldspathic sandstone beds and beds of mottled shale.

[7] Broadhead, G. C., op. cit.

FACTORS AFFECTING LABORATORY MEASUREMENT OF PERMEABILITY OF UNCONSOLIDATED GLACIAL MATERIAL[1]

ROBERT D. KNODLE
Illinois State Geological Survey, Urbana

Introduction

Many noteworthy contributions have been made by scientific research on the flow of fluids through porous media. The work has been mainly in two categories, consolidated material and filtration materials, with less attention to unconsolidated water-bearing materials. Many of the same problems confront the worker in all three fields, and much of the information and many concepts are interchangeable. There are, however, certain problems in the study of unconsolidated water-bearing deposits which are not encountered in the study of either filtration or consolidated material. The consolidated material tends to be more uniform in character (excluding materials with secondary porosity). Filtration material may be sorted, stratified, and of varying shape to obtain the desired results or effects. In natural unconsolidated water-bearing material, a marked heterogeneity is usually encountered; therefore a more empirical approach is necessary in their study.

Properties of Sediments

Classification.—Numerous methods have been devised to describe and classify sediments. Some are extremely useful whereas others are of limited use and little practical value. A brief review of some of the criteria is necessary to ascertain those which are pertinent to the present study. Krumbein[2] says of the mass properties of sediments, "Just as the behavior and functions of a complex organism are the sum of the behavior and functions of the component cells, so also is the character of the aggregate sediment (or any other particulate substance) a summation of the characters of the individual particles or grains of which it is made."

Packing.—An important factor which exercises control over both porosity and permeability is packing. Graton and Fraser[3] have recognized two classifications of packing, systematic and random. They have recognized six basic patterns for systematic packing, which range from loosest to closest packing. Random or disorderly packing is far more common in nature and therefore of more interest to the hydrologist and geologist.

They further state[4] that haphazard packing being of higher porosity than tighter rhombohedral packing has a larger average size of voids;

[1] Published with the permission of the Chief, Illinois State Geological Survey, Urbana, Illinois and based, in part, upon Master's thesis, University of Illinois.

[2] Krumbein, W. C. and Pettijohn, F. S., Manual of sedimentary petrology, p. 498, D. Appleton-Century Company, New York, 1939.

[3] Graton, L. C. and Fraser, H. J., Systematic packing of spheres with particular relation to porosity and permeability: Jour. Geol. vol. 43, pp. 485-800, 1935.

[4] Op. Cit., p. 876.

therefore it has a higher permeability. Since most haphazard packing is systemless, the voids are generally of non-uniform size, producing a higher permeability than systematic packing of the same porosity.

Porosity.—Porosity is the percentage of pore space in the total volume of the sample, i.e., the space not occupied by solid mineral matter. Fraser[5] has listed the following seven factors which control the porosity

1. Absolute size of grain.
2. Non-uniformity in size of grain.
3. Proportions of various sizes of grains.
4. Shape of grain.

Factors of more general nature include:

5. Method of deposition.
6. Compaction during and following deposition.
7. Solidification.

Size.—Slichter[6] in his theoretical work came to the conclusion that the absolute size does not affect the porosity. The factor which has been overlooked is that spherical particles were used instead of natural grains. Actually as grain size decreases, friction, adhesion, and bridging become increasingly important because of the higher ratio of surface area to volume and mass. Therefore, the smaller the grain size, the greater the porosity. Lee and Ellis[7] made determinations on 36 samples ranging from coarse sand to silt with the following results in percentage of total voids: Coarse sand, 39-41 percent; medium sand, 41-48 percent; fine sand, 44-49 percent; fine sandy loam, 50-59 percent. The average of the thirty-six samples was 45.1 percent. Smaller particles were found to give values ranging from 50 to 95 percent.

The variety in grain size in proportion of various sizes and degree of assortment must be taken into consideration in any study of porosity. A mechanical screen analysis can best express these variations.

Hazen,[8] in his experimental soil work, devised a method of gaining a simple quantitative expression of the degree of uniformity which he calls the uniformity coefficient. This is the ratio of the diameter of a grain that has 60 percent by weight of the sample finer than itself to the diameter of a grain that has 10 percent finer than itself. Results of other workers[9] have shown that the values used by Hazen are not always applicable to all types of material. However, the variation is so slight that it does not seem necessary to change the values. Hazen further noted that uniformity coefficient would range from a value of 1, if all particles were of the same size, to 20 or 30 for heterogeneous material; that is, the coefficient increases as porosity decreases. A rough estimate of the open spaces can be made from the coefficient of uniformity. Sharp-grained materials having uni-

of natural unconsolidated deposits.

[5] Fraser, H. J., Experimental study of the porosity and permeability of clastic sediments: Jour. Geol., vol. 43, p. 916, 1935.

[6] Slichter, C. S. Theoretical investigation of the motion of groundwaters: U.S.G.S., Nineteenth Annual Report, 1897-98.

[7] Lee, C. H. and Ellis, A. J., Geology and groundwaters of the western part of San Diego County, California: U.S.G.S., Water Supply Paper 446, pp. 121-23, 1919.

[8] Hazen, Allen, Some physical properties of sands and gravels with special reference to their use in filtration: Mass. State Board of Health, 24th Ann. Rept., p. 50.

[9] Terzaghi, Karl and Peck, R. B., Soil mechanics in engineering practice, pp. 21-22, John Wiley and Sons, 1948.

formity coefficients below a value of 2 have nearly 45 percent open space as ordinarily packed, and sands having coefficients below 3 as they occur in banks, or artificially settled in water, will usually have 40 percent open spaces. With more mixed materials the closeness of packing increases until, with a uniformity coefficient of 6 to 8, only 30 percent open space is obtained, and with extremely high coefficients almost no open space is left. With round-grained water-worn sands the open space has been observed to be from 2 to 5 percent less than for sharp grains of similar size.

Permeability.— Permeability as defined by Tolman[10] is the capacity of water-bearing material to transmit water, measured by the quantity of water passing through a unit cross-section in a unit time under a 100 percent hydraulic grade. Many factors influence the permeability, including size of interstitial openings, continuity of openings, surface tension, capillarity, size of grains, absolute viscosity of fluid (in centipoises), and dissolved gas. It is beyond the scope of this paper to delve into all the hydrologic aspects, but they should be recognized. Although dependent on porosity, there is no direct ratio between porosity and permeability. Terzaghi and Peck[11] have stated that "when a soil is compressed or vibrated, the volume occupied by its solid constituents remains practically unchanged, but the volume of voids decreases; as a consequence the permeability of the soil decreases."

[10] Idem, p. 114.
[11] Idem, p. 44.

With openings of capillary and sub-capillary size the molecular attraction of water molecules is sufficient to "lock" the water in the interstitial spaces.

Surface tension of fluids.—Surface tension in fine-grained sediments exercises important control. It has been estimated by King[12] that the surface area in a cubic foot of sand composed of particles 0.02 millimeter in diameter is about 50,000 square feet. It is apparent that a considerable amount of water can be contained as a thin film on the surface of the grains of such fine material, and that molecular cohesion causes any remaining interstitial space to be filled with captive water. It can be demonstrated that in a given volume of material in which all factors other than size remain equal, the total interstitial space varies inversely with the size of the interstices. A half-inch sphere has one-fourth the surface area of a one-inch sphere, but a container of one cubic inch capacity will hold eight half-inch spheres which in effect doubles the interstitial surface.

Shape.—The shape of particles is known to affect both porosity and permeability, but thorough quantitative work on this aspect has been meager.

Shape studies.—Shape studies[13] were conducted to see whether a measurable quantitative relationship exists between shape, porosity, and permeability. An arbitrary scale[14] was set up based upon three shapes,

[12] King, F. H., A text of physics of agriculture, Madison, Wis., p. 124, 1900.
[13] Wadell, H., Sphericity and roundness of rock particles: Jour. Geol., vol. 41, pp. 310-331, 1933.
[14] Rittenhouse, Gordon, Analytical methods as applied in petrographic investigation of Appalachian Basin, U.S.G.S., Circular 22, March, 1948.

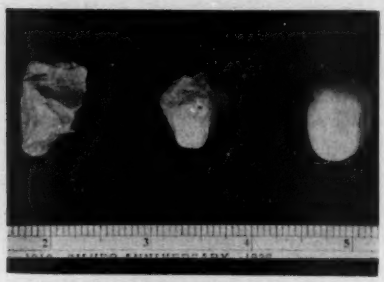


FIG. 1.—Selected pebbles used as a guide in shape studies.

rounded, semi-rounded, and angular. Three specimens were picked from the samples and photographed. This photograph (fig. 1) was used as a guide in further grain counts.

A piece of metric cross-section paper placed between two pieces of lucite served to delineate a given area. Small portions of a sieved sample were placed on the ruled piece of lucite and examined under a microscope. Grains within a given area were counted and an estimate was made of the percentage of each of the three shapes. A less rapid but more accurate method would be to make counts from photomicrographs.

METHODS OF ANALYSIS

It can be readily seen that to the hydrologist permeability is much more important than porosity. A sediment which possesses porosity but not permeability is useless as an aquifer.

Numerous graphical and statistical methods have been devised by various workers in an attempt to analyze sediments. A review and appraisal is desirable to ascertain which of these methods is pertinent to the present problem.

Mechanical size analysis.—Two common and widely used statistical devices are the histogram and the cumulative curve. There are certain limitations and variations attendant to these methods, some of which are discussed below. Udden[15] was among the first workers in the field of sedimentation to use histograms. He observed that histograms of sediments varied considerably according to the type of sediment involved. Beach sands have well defined modes whereas glacial till fractions are widespread and irregular and often bi-modal. One of the greatest difficulties involved in the use of the histogram is caused by the choice of class intervals used in an analysis, i.e., its shape varies according to the particular class limits which are chosen. It is therefore quite possible to construct two very unlike histograms from the same sediment merely by using different class intervals. The basic difficulty with the histogram is that it appears to illustrate continuous frequency distribution as though it were made of discrete classes. Hence the histogram may not furnish much visual information about the frequency distribution considered as a continuous variation of size.

The use of the cumulative curve was prompted by the difficulties encountered in the histogram. This curve remains fairly constant regardless of the class limits used, whereas the histogram is definitely affected by a choice of class limits. Thus the cumulative curve is a much more reliable index of the nature of continuous distribution of particles of sediment. Another advantage of

[15] Udden, J. A., The mechanical composition of wind deposits, Augustana Library Publications, No. 1, 1898.

this curve is the ease with which other statistical data may be derived from it.

Size analysis coefficients.—One of the most valuable measures is that of the median, which is the mid-point in size distribution of the sediment of which one-half by weight is composed of particles of smaller diameter than the median and one-half is composed of particles larger than the median. This is readily obtained from the cumulative curve by noting the diameter at the intersection of the 50 percent line and the curve. This value is used in the recommendations for well screens by the Illinois State Geological Survey.

Skewness, or the measure of the degree of asymmetry of the cumulative curve, has been recommended by some as a method of ascertaining the sorting; that is, a positive skewness indicates that a preponderance of the sample lies on the coarse side of the median. A negative skewness would indicate the opposite. The use of skewness currently has little practical application, mainly because relatively little is known of this character of sediments. Sampling errors, selective transportation, and other factors often manifest themselves as skewness.

Effective size was a term developed by Hazen[16] in his work on filtration sands to designate the diameter of the size particle of which they were 10 percent of the sample by weight smaller and 90 percent by weight larger. Although this measurement was derived for use on a certain sediment, it has with some modifications been quite generally accepted. The effective size is readily obtained from the cumulative frequency curve by ascertaining the point at which the 90 percent line intersects the curve. Hazen justified the choice of effective size upon his observations that the finest 10 percent of a sample has as much effect on the properties as the coarsest 90 percent.

Trask[17] has proposed a method of expressing the measure of the average quartile spread, the coefficient of sorting. It is determined by the square root of the third quartile diameter divided by the square root of the first quartile diameter. This method eliminates the size factor, that is, differences in coarseness between samples or units of measures have no effect on the coefficient of sorting. This method gives a relative idea of the sorting in terms of well sorted (less than 2.5), medium sorted (about 3.0), and poorly sorted (4.5 or more), but fails to give an accurate quantitative measure.

Krumbein and Monk[18] conducted experiments on unconsolidated glacial sediments to determine the effect of size perameters on permeability. The results of their work are of little value in this study because their samples were artificially compounded to fit a predetermined curve, that is, the sieve separates were mixed so that the mean and standard deviations could be varied at will.

Drilling and sampling techniques. The technique in obtaining well samples varies greatly from the techniques used in other methods of sam-

[16] ...em, p. 432.

[17] Trask, P. D., Origin and environments of source sediments of petroleum: Nat. Research Council, Rept. Comm. on Sed., pp. 67-76, 1932.

[18] Krumbein, W. C. and Monk, G. D., Permeability as a function of size perameters of unconsolidated sand: Amer. Inst. Min. Met. Eng. Inc., Petroleum Technology, July, 1942.

pling. It is impossible to remove the material of well samples in an undisturbed condition. Material which has slumped from higher levels in the well bore often contaminates the samples, and drilling bits often pulverize or otherwise disintegrate particles, thus distorting their true magnitude.

The type of drilling tools, the methods used, the size (diameter) of the hole, and the type of well (test hole or producing well) must be considered in the study of any given sample.

Most wells are drilled by one of three different methods—rotary, cable tool, and reverse hydraulic. Certain characteristics of each method merit discussion.

Cable tool or percussion drilling is accomplished by repeated raising and dropping of a bit and a heavy string of tools suspended on a cable or by driving casing and cleaning out the debris as the casing is forced downward, or often by a combination of the two operations.

It is difficult to obtain representative samples from cable tool bore holes. The upper portions are often drilled "dry," that is, with just enough water to facilitate drilling and bailing operations. When a water-bearing sand is encountered, the bore hole is loaded with fluid to, or in excess of, hydrostatic balance with the formation in order to prevent heaving. Heaving can cause drilling difficulties as well as contamination of samples. The constant influx of sand from a heaving formation makes it difficult or impossible to ascertain the true position and character of the water-bearing zone. Excessive disintegration of material is often caused by certain operations of the drilling procedure. Casing set with a drive shoe tends to disturb the formation, and failure of the bailer to remove cuttings exposes them to repeated blows from the drilling bit. The importance of a good and experienced driller cannot be overemphasized. It is generally the driller who collects samples, and the validity of the samples is largely dependent on his care, knowledge, and experience.

In rotary drilling, mud is of prime importance. Many holes drilled in glacial drift utilize as drilling mud the clay material found in the upper portion of the drift, adding only water. When sandy zones are encountered, additional fine-grained material, such as bentonitic clays, must be added by the driller to maintain the mud at the proper weight and viscosity and to remove the cuttings. In some cases, lime, cement, or other materials may be added to increase viscosity or weight.

Care in removing samples is necessary. A device similar to a wire box is generally used to slow up the flow of mud sufficiently to allow even the finer parts of the sample to settle before the sample is removed.

Hole size is an important consideration in the study of well samples. For example, in the large diameter wells drilled for the Illinois Water Service Company, a larger percentage of coarse particles were brought up and a larger percentage of fine particles were washed away than in the 4-inch rotary test holes drilled on the same sites.

As would be expected, information from a test hole tends to be more reliable. More care is taken in sam-

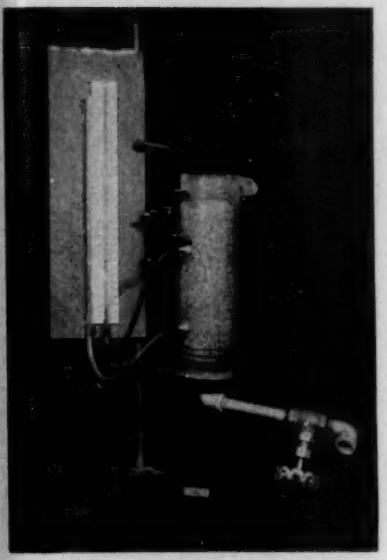


FIG. 2.—Device for measuring permeability of unconsolidated material.

pling and in other techniques. In most final wells, production is the ultimate goal. Large diameter wells produce so much material that a considerable disposal problem results, and it would be necessary to conduct a regular sample splitting procedure in order to obtain a representative sample.

RESULTS OF STUDIES

Permeability. — Samples used in the permeability experiments were composite samples derived from the entire water-bearing portion of University of Illinois Well No. 10. A limited number of readings were taken on 60- and 80-mesh sands and BB shot. It was of interest to note the slight variation between loosest and closest packing in the case of the 60- and 80-mesh separates. When wet samples were introduced into the permeameter containing water, they settled in a state of closest packing and any attempts to lower the permeability were fruitless.

Permeability testing.—Permeability was measured by allowing water under a 100 percent gradient to pass through a sample of known cross section and height, and measuring the amount which was passed in a given time. A permeameter was constructed of a lucite cylinder with an inside diameter of approximately 6.4 cm. and a length of 30 cm. A disc of lucite was bonded to the bottom of the tube and tapped for a ⅜ inch street *el* to which was connected a gate valve. Approximately one inch from the bottom of the tube a piece of 60-mesh wire was placed between two rings of lucite and reinforced with hardware cloth. Above this screen two openings were tapped 10 cm. apart and connected to manometer tubes which were mounted on a board with metric scales (fig. 2).

The major problem was obtaining uniform and accurate readings. To accomplish this a system of "average readings" was devised. Material was introduced into the tube in a steady stream until the top manometer opening was covered. No attempt was made to pack the material further. Water was then introduced into the tube from the top until a steady stream was obtained at the outlet, at which time a reading was taken. This first reading was taken immediately after a continuous flow was obtained through the gate valve, and recorded the permeability of the material in loosest packing.

After the permeability of the material was obtained in a condition of

loosest packing a "Vibra-Tool" was used to jar the material into the closest packing possible. The flow of water was stopped during the packing process to prevent the possibility of channeling. When the closest packing possible was obtained another reading was taken. The average of the two readings was then calculated, which, in the opinion of the writer, represents most closely the original permeability of the material in place in the ground. This conclusion was reached after it was demonstrated that it was possible to produce in the laboratory both looser and closer packing than a sediment possessed in nature. By using an average of loosest and closest packing it was possible to obtain more uniform results than could be obtained by attempting to pack each sample to a uniform standard.

Several experimental readings were made in order to develop a standard procedure which would give uniform results. It was found that false results could be obtained by surging the column of sediment and allowing a relatively complete sorting to take place in the tube. Channeling was common when higher velocities were used. These channels, when developed, allowed water to flow through the column of material in a quantity far greater than in unchanneled material.

The necessity for a gate valve to control the rate of flow of water through the column of material became apparent immediately. Materials of high permeability allowed turbulent flow to develop, introducing error into the results. A high rate of flow also allowed sorting and channeling to occur, causing intolerable errors. Several readings were taken on one sample allowing different amounts of water to flow through the tube in a given time; in all cases the results were well within the limits of probable error. It was then decided to use as low a rate of flow as would register a head on the manometer gauges, thus minimizing any effects due to turbulent flow or sorting.

Hydrologic tests.—A non-equilibrium formula for determining permeability and transmissibility by well pumping tests has been developed by Theis[19] and others. This formula has been applied to a number of well tests in Illinois and apparently gives a relatively reliable indication of the permeability and transmissibility of glacial drift aquifers in place. The values so obtained are controlled by the local natural variations in porosity and permeability (and packing) plus whatever changes may have been caused by drilling and development techniques at the particular site. In one instance in the Champaign-Urbana area, the calculated transmissibility based upon the Theis formula lies about half way between the limits of permeability determined in the laboratory for maximum open packing and maximum closed packing determined with materials from the well. Other cases indicate that the aquifer transmissibility based upon such pumping tests can always be expected to be within such limits, but that the production from a well cannot be predicted from laboratory analysis.

Several factors govern the amount of water which may be derived from

[19] Idem, pp. 519-524.

a formation. Of these, proper development of the well is of great importance. In sand and gravel strata it is quite possible to over-develop a well to a point where a failure is caused in the "roof" or overlying formation. If the overlying formation is composed of clay or extremely fine sand, this material will enter the well bore, causing the material near the well to be clogged and reduced in permeability. Over-development may also cause a bridging of the fine particles between the larger ones. This condition can be generally remedied by surging, and is not considered as detrimental to the yield as roof failure.

Under-development may also cause a low yield. This occurs when insufficient pumping and surging fails to cause relatively complete sorting.

Size range of the particles and thickness of the formation have great effect on the yield of a well, as noted above. Material with great uniformity of particle size will not yield much more water after development than before.

The amount of water available and the diameter of the well are important factors in determining the yield of a well. If there is sufficient water, it is possible to utilize large diameter wells which are capable of transmitting larger quantities of water to the surface than wells of smaller diameter. A thick formation for obvious reasons is capable of containing more water than a thin one.

The factors concerning the development of wells are largely dependent on the skill and experience of the driller. In any study it is important to take cognizance of this factor.

In the shape studies conducted by the author, it was possible to determine accurately the percentage of rounded, semi-rounded, and angular grains in any given sample. However, in any consideration of porosity and permeability, the indeterminate factor of packing still remains. When dealing with uniform spherical particles Graton and Fraser[20] have shown that there are six types of systematic packing, and that porosity and permeability are definitely related to packing. Instead of dealing with six combinations as in the ideal case, it appears that in glacial drift, which is neither uniform nor spherical, an infinite number of combinations of packing can exist. Due to the extreme variability of size and shape, classification as to packing is meaningless. Therefore, any attempt to predict porosity and permeability of a finished well from laboratory samples by any mathematical or experimental process is impracticable.

Summary and Conclusions

Experimental procedure in attempting to produce uniform permeability readings illustrated very clearly that the permeability determinations in the laboratory are not indicative of the actual permeability in the formation surrounding the well bore. An experienced driller, by properly developing a well, causes its yield to differ greatly from those indicated by laboratory permeability results.

The development of a well consists of increasing the permeability of the formation in the vicinity of the well bore, which may be done by pumping and surging to remove the

[20] Idem, pp. 785-800.

fine particles from the vicinity of the well bore. The coarser sand or gravel remain behind the screen in the well bore. The entire water-bearing formation for a wide area around the well is made more uniform in grain size, affording the greatest possible voids for the water to pass through. In proper development the size of the particles gradually decreases with distance from the well bore, and the particles become firmly lodged together and stabilized so that no further change occurs. It appears impossible to predict accurately the amount of water which may be derived from a well treated in such a manner, although experienced drillers can often make remarkably accurate estimates.

After due consideration of existing studies and in the light of the present study, it becomes apparent that there is no way to evaluate quantitatively and accurately the effects of such features as roundness, size, shape, porosity, and permeability in a heterogeneous or non-uniform material with respect to its ability to produce water. In all previous works of this nature the material studied was either artificial or the original character of the natural sediments was altered to conform to desired conditions. While these studies are of academic interest they have been found to be of small value to the practicing groundwater geologist.

The use of compound samples was considered best because the production figures computed for a water well represent only the production obtained from the entire section rather than production from any single stratum.

It is concluded that the use of grain shape in predicting the yield of a formation is not practical because the effect of shape on permeability is exceeded by the effects of grain size and the manner of packing. In evaluating the factors which control porosity, permeability, and well productivity from glacial drift aquifers, it is apparent that for any given texture the effect of packing is of sufficient magnitude to minimize the effects of all other factors, so that the primary influence on an aquifer's productivity are the original conditions of deposition and its subsequent history as affecting its packing.

ACKNOWLEDGEMENT

The author wishes to express his gratitude to Carl A. Bays, formerly Head of the Division of Groundwater and Geophysical Exploration of the State Geological Survey, for his many suggestions and the critical reading of the manuscript, to the individual members of the groundwater division staff for consultation and suggestions, and to H. E. Hudson and H. F. Smith, engineers of the State Water Survey Division, for data, suggestions, and criticism.

FACIES ANALYSES OF THE NIAGARAN ROCKS IN ILLINOIS

HEINZ A. LOWENSTAM
University of Chicago, Chicago

The Niagaran exposures in Illinois, which occur widely separated in the northeastern, northwestern, west-central, and southwestern parts of the State, contrast sharply in gross lithologic aspects as well as local facies development. The differences in gross lithology are basically expressions of broad regional facies differentiations. These regional sedimentation conditions are greatly modified in the two northern outcrop sections by a local environmental factor, the reefs, which formed local sediment sources. Complex small scale facies differentiation characterizes the reef enclosing strata here, indicating further the controlling effect that the reefs had on the sedimentation of the surrounding bottoms. These reef-bearing northern deposits stand out in sharp contrast to the reef-free southwestern Illinois deposits. The southwestern Illinois deposits consist entirely of normal shelf sediments, whereas the reef-bearing portion of the northern Illinois sections embrace reef and inter-reef deposits.

In broad environmental terms we may distinguish three major categories in the facies analyses: normal shelf deposits, reef deposits, and inter-reef deposits.

The normal shelf deposits consist principally of two recognizable source components: (1) terrigenous clastics, derived from the bordering land areas, and (2) skeletal debris, both calcareous and siliceous, supplied by the organisms that populated the shelf bottoms. The terrigenous clastics were apparently derived chiefly from the Appalachian upland or its southern extensions, and to a minor extent from the Ozark Island that existed in Niagaran time. Only in the Ozark bordering outcrop areas in southwestern Illinois do we find evidence of a major contribution of Ozark derived sediments. As to the other outcrop areas, their contributions appear to have been largely confined to the Joliet deposits of west central Illinois and the basal Joliet deposits of northeastern Illinois. There is no evidence at present to warrant the recognition of a chemical precipitate constituent in the carbonate fraction of the normal shelf deposits.

The reef facies differs radically from the shelf facies, as well as the inter-reef facies, in that it constitutes isolated bodies of essentially pure carbonate rock which is entirely organic in origin except for the secondarily introduced magnesian element. The reef frame was erected solely by reef-building organisms, principally stromatoporoids and tabulate corals, which produced rigid topographically raised structures that extended from the surrounding bottoms upward into the agitated surface waters. The interstices of the reef frame are largely filled with organic skeletal debris of reef dwell-

ing organisms and reef detritus, which occur commonly cemented into the frame by encrusting stromatoporoids. The reef bodies are commonly found flanked by reef-derived detritus. Secondary dolomitization has greatly altered the original textures and largely obscured the organic character of the reef bodies.

The inter-reef facies, up to the present ill-defined and interchangeably referred to as normal or lagoonal facies, may be broadly defined as the deposits which accumulated within the orbit of the detritus laden waters of reef outwash. The inter-reef deposits thus embody two distinct source elements, a regional and a local reef-derived one, the latter forming the most characteristic criterion for distinguishing the inter-reef facies from the normal shelf facies.

With this as a background, the facies of the individual outcrops may be analyzed.

Beginning with the northeastern Illinois outcrops, the Niagaran deposits consist of a succession of normal shelf deposits through the Joliet formation, which gradually gave way in the Waukesha transition phase to reef and inter-reef development in the Racine-Guelph formations. The regional environmental factors which can be deduced from the gross character of the sediments as a whole are fairly muddy waters (as indicated by the average of 15-20 percent terrigenous clastics) and soft muddy to sandy bottoms, generally lying slightly below effective wave base. Reef growth started in sporadic form during Waukesha deposition, which is marked by semi-rough water conditions and the influx of coarse silt and very fine sand. Curiously enough the main phase of reef development came only after lowering of the sea bottom below wave base, implying that deeper bottoms and fairly muddy waters were not detrimental to the Niagaran reef builders. Complex facies differentiation goes hand in hand with the main reef development, the inter-reef facies shifting horizontally and vertically in correspondence to the shifting reef spread. The inter-reef deposits are characterized by sharp horizontal facies differentiations ranging from quite muddy deposits of anaerobic through aerated quiet water facies all the way to rough-water deposits which are principally composed of reef-derived detritus. The inter-reef deposits thus contrast sharply with the early Niagaran normal shelf deposits; such facies changes as were gradually attained in time but not in space in the shelf deposits can be commonly found developed over short distances in the horizontal plane among the inter-reef deposits.

In the northwestern Illinois section, the Niagaran deposits also consist of a succession of normal shelf deposits in the Waukesha formation, followed by reef and inter-reef development in the Racine-Port Byron sequence. The facies contrast between normal shelf, reef, and inter-reef deposits is here less sharply defined, the chief contrasting features being sediment structures and facies shifts. This is primarily due to the negligible content of terrigenous clastics which average here less than 5 percent. Textural and composi-

tional criteria readily recognizable in limestones, which would aid in the analyses of a more detailed facies differentiation, have been obscured by secondary dolomitization. The broad environmental factors that characterize (and at the same time contrast) the northwestern and northeastern Illinois deposits are prevalent shallow-water bottoms, located largely above wave base, and clear water conditions. During the prevailing intervals of shallow water conditions, reef detritus was spread and redeposited entirely over the adjacent inter-reef bottoms, largely in the form of shifting sand bars rather than in detrital fans which, however, accumulated around reefs during periods of temporary subsidence below wave base.

The Niagaran deposits of west-central Illinois, as far as preserved, underlying the pre-Middle Devonian erosion surface, consist entirely of normal shelf deposits. As even the most extensively preserved sections in the Grafton area do not extend upward into the horizons of the reef-bearing strata in the northern outcrop areas, it is uncertain whether reef and inter-reef facies were originally present or not. The sections in the Hambury area consist of crinoidal limestone coquinas, of the semi rough-water type, whereas the Grafton deposits comprise dolomitized rough-water deposits at the base followed by semi rough-water deposits of the Waukesha facies type as developed in northeastern Illinois.

The southwestern Illinois deposits are represented in their entirety by normal shelf deposits in which the carbonates consist of limestone. Following an intial phase of semi rough-water conditions marked by clastic semi coquinas, the bulk of the succeeding section is composed of muddy bottom, quiet water deposits, evidently laid down at greater depth than any of those of the other outcropping areas. The prevailingly low density in burial population (consisting of small fragile forms) and lack of evidence of large scale reduction of the terra rosa muds derived from the adjacent Ozark upland point toward deposition under quiet water conditions, near or at the photosynthetic ceiling. Because of the pronounced muddiness, reflected in the terrigenous clastic content of about 40 percent, a considerably higher average than in any of the other areas, the photosynthetic ceiling was evidently above 600 feet, appreciably higher than its maximum extent under clear water conditions.

PHYSICAL CHARACTERISTICS OF THE OOLITE GRAINS OF THE STE. GENEVIEVE FORMATION*

RAYMOND S. SHRODE
Illinois State Geological Survey, Urbana

The usual hand specimens and thin sections of oolite afford randomly oriented cross-sections of the oolite grains and permit observation in one plane only. They give inadequate information therefore regarding the size, shape, or roundness of the grains. It was found that "chalky" oolite could be successfully disintegrated to yield a high percentage of discrete grains by a procedure known as the "sodium sulfate soundness test"[1] which duplicates roughly the disruptive action of freezing water but produces disintegration more rapidly. The quarry at Anna, Illinois, contains in its upper part a bed of Ste. Genevieve oolite 6½ feet thick which responded well to this procedure. This paper describes the results of a study of the oolite grains freed from six samples taken from the bed, each sample representing a vertical thickness of about 12 inches.

After disintegration each sample was screened into Wentworth size-scale fractions and weighed. The weight and number of oolite grains in a small weighed quantity of each size fraction was then determined and their particle size distribution calculated in percent by weight and percent by number.

Two matters bear critically on the confidence with which subsequent data may be regarded, namely, is the number of unbroken, discrete oolite grains proportionate to the number in the original sample, and to what extent did the disintegration process reduce the size of the freed grains by exfoliation of concentric deposits. Estimates of the abundance of oolite grains indicate that the number freed is roughly proportionate to the number in the original sample. Signs of exfoliation were generally absent in the discrete grains. This evidence and the excellent preservation of small fossils freed along with the oolite grains suggest that exfoliation was probably not an important phenomenon.

Size of Oolite Grains

The results of particle size determinations on the oolite grains in the six samples are shown in Figure 1. Most of the grains are between 0.25 and 0.83 millimeter in diameter. In terms of the Wentworth size scale for sediments, the grains are principally medium and coarse grained if considered on the basis of percent by weight. However, in terms of percent by number the dominant size is medium grained.

The particle-size histograms of the different samples show no consistent trend from the top of the bed downward. Mostly such variations as occur are between the medium- and coarse-grained grades.

The bedding and other characteristics of the stratum from which the

[1] A.S.T.M., Designation C88-46T.

* Published with the permission of the Chief, Illinois State Geological Survey.

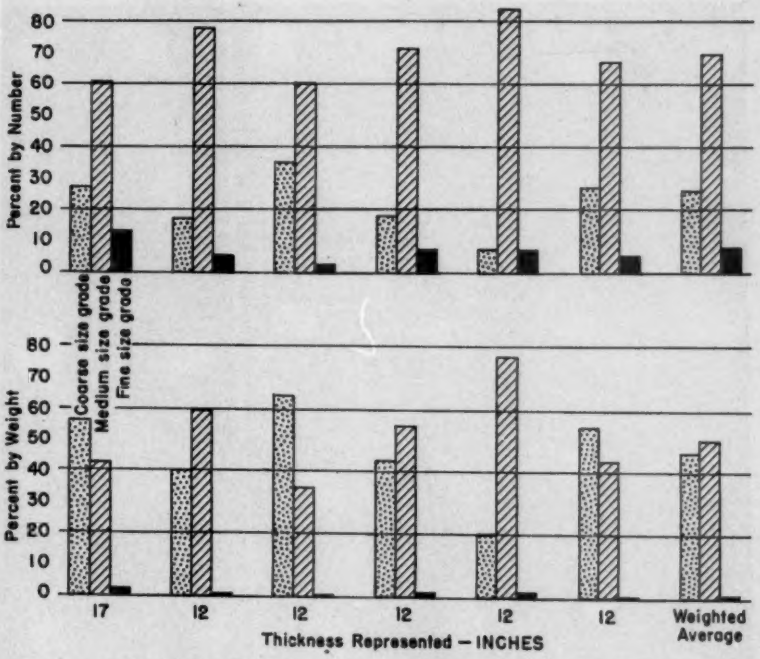


FIG. 1.—Particle-size distribution of oolite grains by weight and number. Reading from left to right the histograms progress from the top of the bed downward.

samples studied were obtained show clearly that it is a clastic rock. The particle-size data indicate conditions of sedimentation which appear to be even more selective than those under which a medium- and coarse-grained sand would be deposited. The restricted size range of the majority of the grains, about 0.6 mm., may be the result of either a high degree of sorting by the transporting medium, limiting factors controlling the maximum and minimum size of oolite grain development, or a combination of both. Erosion during transportation might also be responsible, at least in part, for the grain-size distribution. If this were true, very fine-sized oolite grains should be present. Also, some grains should show evidences of erosion, such as exposure of their internal structure. As neither of these phenomena was observed it is concluded that erosion of grains did not significantly affect particle-size distribution.

Taken together, the foregoing data suggest that the source of the oolite grains was not far from their site of deposition, that they were transported by relatively strong currents or waves, and that conditions in the area of oolite grain formation may have been such as to restrict maximum and minimum oolite size, especially the former.

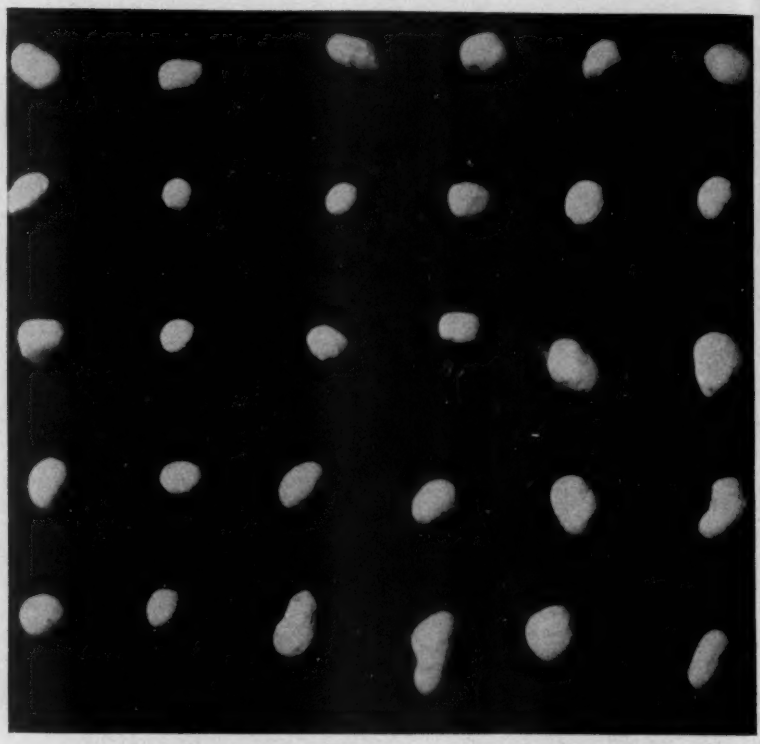


FIG. 2.—Typical oolite grains from the coarse size grade. X 10.

SHAPE AND ROUNDNESS OF OOLITE GRAINS

Roundness determinations were made from photographs of 60 grains of each size category selected at random from the various samples. Figure 2 shows grains of the coarse sand grade. Figure 3 gives the results of classification of the grains by Krumbein's scale for roundness determination.[2] The arithmetic mean roundness values on the chart are very similar and indicate little difference in the over-all roundness of the size fractions. The coarse sand fraction, as shown by the histograms, is notably different from that of the other two size-grades. One difference is the longer 0.9 roundness bar and the shorter 0.8 and 0.7 bars. This may be interpreted as being the result of increasing roundness accompanying the growth of the oolite grains. The reason for the greater percentage of grains with 0.6 roundness in the coarse sand grade is not understood. There is some evidence, however, which suggests that the centers in these oolite grains have

[2] Krumbein, W. C., Measurement and geological significance of shape and roundness of sedimentary particles, Jour. Sed. Pet., vol. 11, pp. 64-72, 1941.

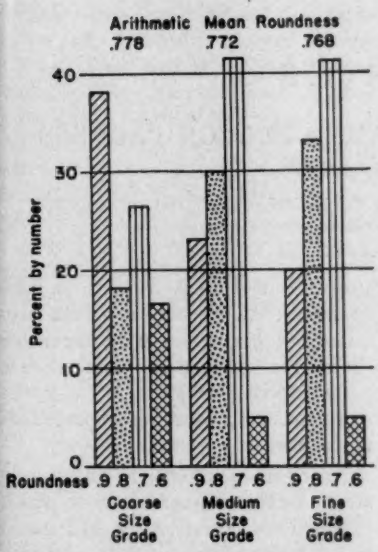


FIG. 3.—Roundness of oolite grains by size grades. Arithmetic mean roundness value is shown above each histogram.

low sphericity, are fossils or comparatively large fragments of fossils, or other types of material, and that the number of concentric deposits is small and therefore insufficient to eliminate the original angularity of the central grains.

Interesting light is shed on the reliability of roundness or shape interpretations from thin sections by a consideration of figure 2. It is evident that random sections through the oolite grains would be very misleading in many cases. A diagonal section through the elongate grains in the upper left hand corner would show an oval cross-section whereas a section at right angles to the long axis would give a circular section. Similarly erroneous results would be obtained with many of the oval or roughly triangular grains.

SUMMARY

The oolite grains of the Ste. Genevieve limestone bed studied have the size characteristics of a well sorted medium- and coarse-grained sand and do not appear to have been transported far. Their roundness values are all higher than 0.5. There is suggestive evidence that the growth of oolite grains is accompanied by an increase in roundness. The three dimensional shape character of the oolite grains suggests that detailed shape interpretations from thin sections may be misleading.

PHYSICS

INVESTIGATION OF A GAMMA-PROTON PROCESS IN BERYLLIUM

RICHARD L. CONKLIN
University of Illinois, Urbana

The experiments here described were performed with the 20-Mev betatron at the Los Alamos Scientific Laboratory, New Mexico. The work was done under the direction of William Ogle, with the invaluable assistance of Leon J. Brown.

Many radioactive substances can be produced artificially by bombarding non-radioactive samples with high-energy nuclear particles. In such a reaction, a bombarding particle can be thought of as evicting part of the nucleus of an atom of the sample, and residing there in its place. For example, if a high-energy neutron enters a nucleus of stable nitrogen (atomic weight, 14; atomic number 7), a proton may be emitted, the product being radioactive carbon (atomic weight 14, atomic number 6). Such a reaction is known in the language of nuclear physics as a neutron-proton, or, more simply, an n-p reaction. Reactions are known involving all the elementary particles, both as projectiles and as displaced nucleons. One of the less frequently observed is the process in which a high-energy gamma-ray causes a proton to be evicted from a nucleus. The betatron would seem to be an ideal source of gamma-rays for the observation of such a so-called γ-p process. Its high, easily controlled energies render it very useful, but there is one serious complication. A great many fast neutrons are associated with the beam from the betatron; these induce radioactivities which may easily be confused with or misinterpreted as the results of γ-p processes.

An effort was made to find a substance in the bombardment of which fast-neutron reactions would cause no confusion. Be^9 seemed to be such a substance. The γ-p reaction on this isotope should yield Li^8, which decays with the emission of beta particles with a half-life of 0.88 sec. Except for He^6, which may be produced in several ways and also emits betas with a half-life of 0.8 sec., all other possible reactions yield products which either break up at once or have extremely long half-lives.

A rough experiment indicated that when beryllium is exposed to 20-Mev gamma-rays from the betatron, an activity is induced, and that it has a half-life of the order of one second.

In order to measure the half-life, the beryllium sample was placed against a glass Geiger counter directly in the betatron beam. With this arrangement, counting could begin a few tenths of a second after irradiation, and a high counting rate was achieved. Since the decay was too fast for visual recording of the

data, a timer and the interpolation lights of a scaling circuit were photographed with a moving picture camera. The film could then be projected at a much-reduced rate, and the number of counts per second determined. (The background due to the activity induced in the counter itself of course had to be subtracted.) The half-life thus measured was 0.88 ± 0.03 sec.

Since it is almost certain that some He^6 will be produced, and since it has a half-life almost equal to that measured, it was necessary to be certain that this was not the activity being observed. He^6 is known to decay with the emission of beta particles with a maximum energy of 3.7 Mev, while Li^8 decays with the emission of betas with maximum energy 12 Mev. Thus, a simple absorption measurement should serve to distinguish the two.

Activities induced in an aluminum absorber would have been very troublesome if the sample, absorber, and counter had been held in the beam, as before. Hence, during irradiation the sample ($3x3x\frac{1}{2}$ inches in size) was placed at the top of a vertical track in such a way that as soon as the betatron was turned off the sample dropped about 9 inches into position in front of the absorber and counter. As it dropped into place it activated the scaling circuit and a time delay which turned the scaler off at the desired time. In this way the number of counts in the interval between 0.3 and 1.3 seconds after irradiation was measured. This was repeated with many different thicknesses of aluminum absorber. An absorption curve plotted from the data indicated the presence of beta particles of energies up to 13 Mev, showing that Li^8 was present. The presence of He^6 was also indicated by the presence of a low-energy component.

To determine the threshold of the reaction, it was necessary to vary the energy of the radiation from the betatron. In our experiment this was done by changing the time of expansion of the orbit, so that the electrons were made to hit the target at some selected time before reaching their full energy. Sensitive timing circuits were available; so the energy could be varied with considerable accuracy over a large range. The intensity of the beam dropped off sharply as the energy was decreased; so the practical lower limit was about 6 Mev.

Using the dropping technique described previously, a curve of beta activity versus maximum bremstrahlung energy from the betatron was run with 5/16 inch of aluminum (enough to absorb all He^6 betas) between the beryllium and the Geiger tube. At the end of each series of runs at a given energy the betatron yield was measured. A curve of counts per unit of irradiation versus maximum gamma-ray energy indicated a threshold of 18 ± 1 Mev, as compared with a theoretical value of about 17 Mev. With no absorber between the beryllium and the counter, an effect was still observed as low as 6 Mev. This was to be expected, as the threshold for the formation of He^6 is about 3 Mev.

Li^8 decays into Be^8, which immediately splits up into two alpha particles. Since there are no alphas associated with the decay of He^6, the observation of the alpha-particles

themselves should be another method of verifying the presence of Li^8.

Since the alphas expected should have energies of only about 1.6 Mev, their penetrating power is very small. Thus the problem in observing them is to irradiate a large amount of beryllium distributed thinly so that a detectable number of the alphas produced may reach a counter. To get measurable intensities, the sample must be as close to the betatron target as possible. The problem was finally solved with some success by constructing a large wheel of micarta and gluing on one face beryllium flakes in a band of 3 inches average width and 12 inches average radius. This wheel was arranged vertically, immediately in front of the betatron, and connected to a small motor in such a way that it could be rotated at four speeds. The radiations were observed with an alpha-sensitive counter placed at the bottom of the wheel. The counter was at such a distance from the beryllium that only alphas with energies greater than 1.6 Mev could reach it. Numerous tests were made to be sure that the counter was not affected by betas, or by electrical pickup from the betatron, motor, and other apparatus. Shielding was a major problem.

Actual measurements were made by observing visually on an oscillograph the pulses made by alphas. Five-minute runs with betatron yield were alternated with five-minute runs with the betatron off but the wheel still rotating. All runs were made at 20 Mev. A definite, though small, effect was observed (less than 10 counts per minute). To make a rough estimate as to the half-life of the observed activity, the wheel was run at different speeds, thus varying the time elapsed in turning a given sample of beryllium from the beam to the counter. No accurate value of half-life could be determined because of the effect of growth of activity as the beryllium crossed the beam, decay as it passed the counter, and persistence of activity for a time greater than one revolution of the wheel. Approximate corrections were made for these, and the half-life was shown to be about one second, as it should be.

ELECTRONIC AIDS TO CONTROL AND MEASUREMENT

HOWARD C. ROBERTS and RICHARD E. WENDT
University of Illinois, Urbana

Many problems in the laboratory involve the measurement of extremely small magnitudes and consequently require delicate and often expensive instruments. Further difficulty is introduced by the fact that such magnitudes often vary rapidly with time, and measuring devices should be capable of following those variations accurately. For many of these measurements, however, it is possible to employ some form of auxiliary equipment which will allow the use of rugged and inexpensive indicating or recording instruments. This paper is a compilation of several such devices, selected for their simplicity, low cost, and utilitarian value.

For the measurement of physical magnitudes other than electrical it is desirable to employ some form of transducing element to convert the magnitude into a proportional electrical signal; this, when amplified and recorded, becomes a record of the physical magnitude. The literature contains much material on simple transducers, therefore only a few general types are listed by broad classes in Table 1.

TABLE 1.—SIMPLE TRANSDUCERS

1. Temperature to electrical signal:
   - Thermocouple.
   - Resistance thermometer.
2. Illumination to electrical signal:
   - Photoelectric cell.
3. Movement or dimension to electrical signal:
   - Variable resistance device.
   - Variable inductance device.
   - Variable capacitance device.
   - Variable illumination device.

It should be noted that although electron tubes are used in these circuits, they are used only where they provide the simplest and most satisfactory method. Care has been taken to employ no circuit components which cannot be obtained from any radio parts supplier. Most of the following circuits are operated from the a-c. line; thus there is no cost for special power supplies. No special tricks in construction are required, although ordinary good practice should be observed. The information given here is adequate for duplicating the circuits. Data in the curves are representative of what may be expected, although some variation will naturally be found from one circuit to another. The circuits are recommended not for their novelty but for their utility; and to this end the designs have been simplified to use the minimum number of circuit elements consistent with good performance.

The first circuit to be described is drawn as figure 1. Here one winding of a transformer is placed in series with a load (or an output device or an instrument) and an alternating current source; its ability to pass alternating current is controlled by the potential of the grid of an electron tube across its other winding. Thus a current of several amperes may be controlled by a small applied potential. With the direct-coupled preamplifier

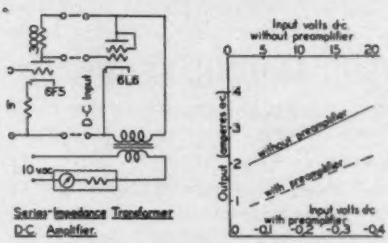


FIG. 1.—Series Impedance Transformer

(shown connected by dashed lines) the control potential may be but a small fraction of a volt. If a direct-current output is desired, a dry-disc rectifier may be added.

Figure 2 shows another device to give relatively large output currents from small input potentials. In this device the cyclic intervals of current flow through a miniature thyratron are controlled by the grid potential. Either a transducing element (i. e., a photocell or a variable resistance) or a second electron tube may be employed in a phase-shift circuit to affect the grid potential. The output of the thyratron tube is pulsating direct current, which may be filtered and applied through a negative feedback circuit to give extremely high stability. In the diagram, however, a transformer and dry-disc rectifier have been introduced into the plate circuit of the thyratron to give many milliamperes of output current at low impedance rather than a few at a potential of several hundred volts.

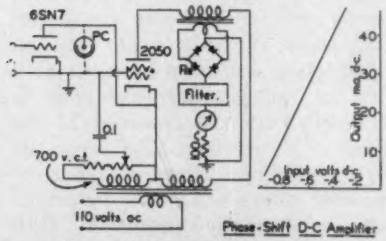


FIG. 2.—Phase-shift Amplifier

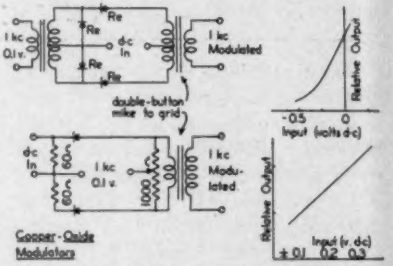


FIG. 3.—Copper-oxide Modulators

The next two circuits, shown in figure 3, may be used to convert the small output of a thermocouple (or any similar potential of a few millivolts) into a current of several milliamperes, easily recorded. An alternating carrier voltage is modulated by the copper-oxide rectifier units, *Re*, as their impedances are changed in response to the direct current flowing through them from the thermocouple. The resulting modulated signal may be amplified to any degree desired and demodulated to give an easily recorded output. Both circuits require a few milliamperes input current at low voltages, unlike the other circuits described, which draw almost no current from their signal sources. The two circuits are not alike, but they perform in much the same manner, as is illustrated by the curves of relative output. It is assumed that ordinarily an amplifier will follow the modulator circuit; it is for this reason that only relative output is shown in the curve.

All of the measuring circuits described in this paper are capable of

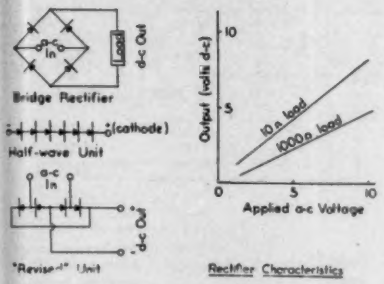


FIG. 4.—Bucking-out Circuits

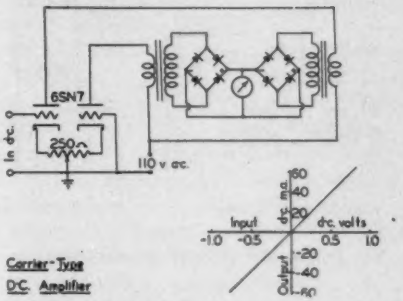


FIG. 5.—Carrier Type Amplifier

following inputs varying at a few cycles per second. In addition, the two circuits shown in figure 3 and the one of figure 5 may be given much more rapid response by increasing the frequency of the carrier voltage. For variations in the measured potential up to about 10 cycles per second the 60-cycle line current may be used; for measuring rapid fluctuations in temperature with a thermocouple, 1,000 cycle carrier supply was used with the circuit of figure 3.

With many of these devices, if the amplifier output is simply rectified for d-c. output, it is often not convenient to adjust the circuit so that the output current becomes zero for a particular input potential. To use the indicating instrument in the most efficient manner it will be desirable to inject a bucking-out current into the output circuit. One convenient method for doing this is shown at the left in figure 4. Here a dry-disc rectifier is supplied with alternating current from an independent source and connected so that its output opposes that from the amplifying device. Adjustment of the bucking-out current is simple, and it is used to establish the zero of the indicating instrument as may be desired. This is often an advantage, particularly with the circuit of figure 1. The circuit at the left is good for large output currents at low voltages; the circuit at the right is better suited to the opposite case.

A circuit basically similar to those of figure 3 but capable of handling more power is presented in figure 5. If the control grids of both triodes are at the same potential, the two plate currents will be equal, and the output of the differencing circuit containing the dry-disc rectifiers will be zero. As the input potential varies, the difference output will vary in proportion. This circuit has sufficient output to actuate an ordinary industrial recording instrument. It is convenient to provide a variable control in the cathode circuit so that individual differences in tubes and rectifiers can be compensated.

It may be helpful to insert at this point a note about the rectifiers used in these circuits. The copper-oxide units used in the modulating circuits are simply small meter rectifiers of the lowest current capacity conveniently obtainable. The rectifiers

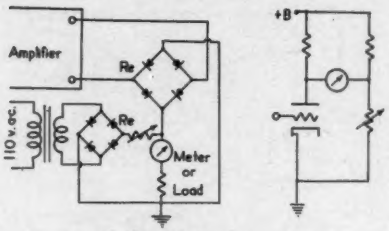


FIG. 6.—Rectifier Characteristics

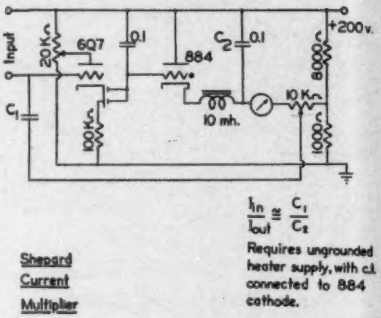


FIG. 7.—Shepard Current Multiplier

used in the output circuits, however, must be capable of handling higher currents and also of withstanding greater back voltages. The small selenium rectifier units now popular for use in household radio repair work have been found suitable for this application. As made, they have either five or six plates connected in series, and they are used as simple half-wave rectifiers; they may easily be disassembled, however, and reassembled to form bridge rectifiers as indicated in the diagrams. The performance curve of figure 6 shows what may be expected of such a "revised" rectifier unit. Ordinary filament transformers (117 volts to 6.3 volts, at 1.5 amp.) have been found completely satisfactory for use as output transformers with these rectifiers; they have been used in these circuits. This is another part of the attempt to simplify the problems of procurement and construction.

The circuit in figure 7 has been termed a "current multiplier" by Frank Shepard, who first disclosed it, and the name describes it perfectly. The feeble input current may be a small fraction of a microampere, from a source of a small fraction of a volt, while the output current is enough to actuate a husky milliameter. The multiplication is controlled by the ratio of capacitors C_1 and C_2. Changes in other components, fluctuations in supply voltages or variations in tube characteristics due to ageing will have negligible effect on the performance of the circuit. In operation, the *6Q7* plate supply is first adjusted by the voltage divider to a value for which the thyratron, *884*, just fails to conduct. If input current is then allowed to flow into capacitor C_1 the circuit will begin a regular series of relaxation oscillations in which the miniature thyratron repeatedly discharges C_2 through the indicating instrument while continually recharging both capacitors from the common power supply.

The last of these circuits, shown in figure 8, is designed to indicate or to measure time intervals, The three neon glow-lamps, *Ne*, are connected in relaxation oscillator circuits containing circuit components so selected that one bulb produces pulses at one-tenth second intervals, one at one-half second, and the third at one-second intervals. Placed side by side and so mounted that their light impinges upon a moving photo-

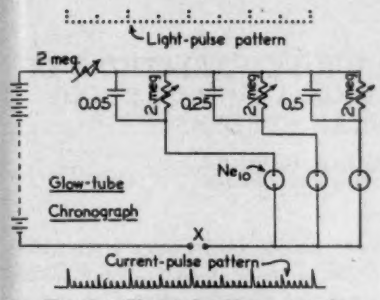


FIG. 8.—Glow-tube Chronograph

graphic film or paper, the device places a time scale on the photographic record like the pattern at the top of figure 8. The current output, taken off at X, may be recorded if desired with some current-sensitive device; its wave-form is like the pattern across the lower part of the figure. Other time scales may be afforded by suitable choice of circuit constants; for the lowest rates it is convenient to employ a small clock-type synchronous motor and a suitable commutator. For those laboratories equipped with seconds clocks a pendulum contact is a simple way of making available timing marks at second intervals only.

The device is capable of quite high accuracy if care is taken in design and in adjustment of the circuits. Because of individual variations in neon bulbs, each circuit must be separately adjusted. Operating current is small and is conveniently supplied by a radio B-battery of about 135 volts. Adjustment for variation in battery voltage is made with the two-megohm rheostat in series with the battery. This also serves to synchronize the pulses at the half-second and full-second intervals. One of the best types of neon bulbs for this use is the one-twenty-fifth watt Type Ne-10 baseless bulb.

With the possible exception of the current multiplier, each of the circuits, when incorporated in a measuring system, must be calibrated by comparison to an instrument whose accuracy is known to be at least that with which the final measurement of the unknown magnitude is to be made. Calibration checks under various conditions will help to detect any lack of stability of circuit components. Line voltage variations must be taken into account or eliminated. Since the performance of the current multiplier depends almost exclusively upon the ratio of magnitude of two circuit elements, knowledge of the value of each will allow the performance to be calculated. A calibration of the device is of value, however, in helping to eliminate whatever error has been incurred in measuring the two capacitors. It must be recognized at the outset that the accuracy of a measurement with one of these devices can never be much better than the accuracy of the indicating instrument used in the output, despite calibration, however often.

In order to secure dependability of measuring systems based on these circuits, every non-essential part has been eliminated and the resulting circuit critically re-examined for possible further simplification to secure maximum reliability. We feel that simplification is to be sought after, for it confers ease of construction and reliability, as well as lower cost.

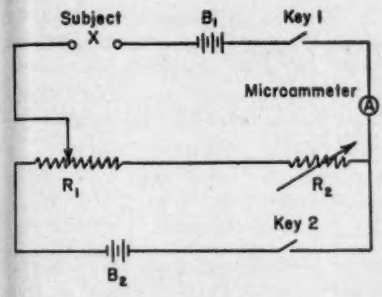
SIMPLE CIRCUIT FOR MEASURING VARIATIONS IN ELECTRICAL RESISTANCE OF A HUMAN BEING UNDER EMOTIONAL STRESS

A. F. SILKETT and MAE A. DRISCOLL
University of Illinois, Navy Pier, Chicago

Variations in electrical resistance offered by the body of a human being under different circumstances of physical and mental stress have been known for some time. Darrow[1] in 1934 described a "reflexohmeter" which was improved upon and modified by Lauer and Anderson[2] in 1937. Many years previous to this, the studies of Leonarde Keeler brought forth the instrument known as the "electrocardiograph."

The Lauer instrument was used for several years in measuring the excitability of persons as one of several factors which were thought to be pertinent characteristics of a good automobile driver. The National Reseach Council, as it was organized at that time, together with the American Automobile Association and the National Safety Council used this device for several years. As an index of the intensity of its use, the author applied the Lauer "Responsohmeter" to some 2,300 persons during one summer. In each case, the instrument was balanced to give a null reading with the individual in the circuit. As the individual's tension increased, the electrical resistance was found to decrease, thus upsetting the balance of the circuit. It might be worth noting here that using palm contacts consisting of cups filled with salt water which were inverted, palm-of-the-hand, up, yield resistances which vary among individuals from about 4,000 ohms to nearly 30,000 ohms, when the cup diameter is approximately 4 centimeters. Under such minor excitations as the noise produced by slapping a desk top sharply with a ruler (behind the testee's back), resistance variations of the order of 2 percent may be expected. If the subject is "nervous," or if the particular stimulus carries great significance in the subject's pattern of evaluations, variations as high as 16 percent of the resistance may be found. Thus, a stenographer who is afraid of her dictatorial boss will show more response to the sound of a buzzer than she will show to a much louder automobile horn.

The principle of the device is that of the simple potentiometer. Two cells of comparable e.m.f. or voltage are connected in opposition to each other, each through variable resistances. The person tested is one of these resistances. Variations in his resistance occur as his perspiration varies. A time lag of from 2 to 7 seconds is observed between the stimulus and the maximum ammeter reading. A new setting or resistance level is used after each stimulus. These new settings are found after the resistance seems to stabilize which is usually a matter of a minute or two after the stimulus is given.



Sometimes a subject professes to be afraid of electrical wires. Of course, the total amount of "electricity" passed through the subject is less than that which redistributes itself in the process of combing the hair. A colleague suggests that "potentials" instead of resistances are responsible for the readings. Failures to date to find any polarity effects make the concepts of "potentials" difficult to accept.

To make the device readily portable, a simple microammeter was substituted for the galvanometer of the convential potentiometer circuit. A microammeter whose range is 0-30 mu when used with 4½ volts and 20,000 ohm resistances has proved to be usable.

Assembled into a portable unit, this becomes an instrument which is useful in motivating students who have occasion to study the potentiometer. It is useful as a means of measuring excitability of persons in unexpected situations—such as the study of characteristics of automobile drivers by Lauer and others. The statement has been made that no satisfactory way of measuring pain has been devised. Perhaps this device may be a step in that direction—at least it can measure the response to pain. It provides a simple means of studying some of the electro-chemical phenomena of human reactions without requiring a puncture or abrasion of the skin for contacts.

Since some interesting perturbations of the ammeter needle have been observed during the early stages of reponse to a stimulus, two proposals have been made for further study. One involves connection with an oscilloscope to study possible oscillotory character of the variations in resistance—or of potentials, if so they be. The other proposal is to incorporate a push-pull amplifier or similar device into the circuit to give greater sensitivity.

A popular usage of this device should not be totally neglected. While reference was made to Keeler at the beginning, it is not the intention to indicate that such a potentiometer circuit alone would be a suitable lie detector. However, the concern which the ordinary individual bears toward the winning of any game will cause enough increase in his perspiration at the palms to readily detect the little "white lie" when he denies his correct age, or similar incident. The usual procedure at social and service clubs is to instruct a subject to choose one number between one and ten. Then he is instructed to deny all suggested numbers. Try to beat it!

[1] C. W. Darrow, The reflexohmeter (pocket type), *J. Gen. Psychol.*, 10, 1934, 238-239.
[2] Alvah R. Lauer and Donald E. Anderson, *Am. Jour. of Psychol.* 51:1, Jan. 1938, 156-159.

SOCIOLOGY

THE STRUCTURE AND INSTITUTIONALIZATION OF A PROTEST GROUP*

FRANK E. HOUSER
Wheaton College, Wheaton

This is a study in the sociology of a protest group. The particular group under study is the Orthodox Presbyterian Church—a religious group which seceded from the Presbyterian Church in the United States in 1936.

In opposing the alleged doctrinal defection in the parent body, some of the dissidents set up an independent mission board for which they solicited funds. By being stewards of a mission enterprise which would send only doctrinally orthodox missionaries to the field, the dissidents ran afoul of ecclesiastical law and were suspended from the ministry of the Presbyterian Church. This nuclear group was joined by other ministers and parishoners of like persuasion. Shortly after its inception, the newly formed church had seventy-five member ministers under its jurisdiction and nine Presbyteries had been erected. They chose to be known as the Presbyterian Church of America.

In the ten years of their existence, the "come-outers" have encountered much rough terrain. Their leader, J. Gresham Machen, died suddenly six months after the first General Assembly in 1936. In the second General Assembly held in November of 1936, a doctrinal dispute developed on premillenarianism versus amillenarianism. This cleavage in the pristine harmony of the new group was deepened when the disputants took opposite sides on two additional thorny questions—Christian liberty in regards to alcoholic beverage consumption, and the "independency" of the Independent Board for Presbyterian Foreign Missionaries. In 1937, as a result of these differences, a sizable group of ministers and elders withdrew from the new church. A third blow came as a result of a complaint by the Presbyterian Church in the United States asking the court to enjoin the group from using the name "Presbyterian Church of America" on the grounds of similarity. The court decided in favor of the plaintiff church. Therefore, in 1939, the present name of Orthodox Presbyterian Church was adopted.

The Orthodox Presbyterian Church has shown some growth. The number of ministers has increased from seventy-five to one hundred and two in ten years. The membership has grown from 4225 in 1938 to 7555 in 1946. Fourteen new congregations have been added.

The primary focus of this study is the institutionalization of the protest group. It is well known that radical protest groups do not remain as such, but gradually lose their

* This paper is an abridgement of an unpublished Master's Essay submitted to Columbia University in June 1948

rough edges until they resemble the more orthodox religious, political, or economic groups in society. What does sociology have to say about such phenomena?

Sociology provides several tools that give insight into the problem. The first concept is that of group structure. Although the dynamic social process of group structure is quite ephemeral, there are "certain of the relationships set up between the members which tend to assume a more permanent character"[1] as the group emerges. This makes possible a static view—somewhat of a cross-sectional view at any one moment of time—which captures the persistent relationships of the group. These relatively permanent relationships "provide the structure in terms of which the more evanescent processes of group interaction are carried on."[2] These more persistent relationships have been termed institutions. For example, MacIver sees them as products or embodiments of the process of social relations. Institutions are "forms or conditions of procedure characteristic of group activity."[3] Therefore, if one examines the early institutions in the life of the Orthodox Presbyterian Church, one has a base-line against which one can compare the increasing complexity and rigidity of structure through the years. This increasing complexity and rigidity is one major facet of institutionalization. Before looking at the structure it is necessary to point out the general character of the protest.

The locus of the protest was in that religious field of expression known as doctrine. The fields of ritual and organization were left alone. Usually secession originates as a protest against conditions in one of these three fields. No significant protest was launched by the dissatisfied group against the social policy of the church. The bulk of the protestations were in the field of doctrine. This fact, combined with the total lack of protest in the realm of organization, goes a long way in explaining the sociological consequences of the secession. The usual types of group organization open to seceding groups are, according to Wach, (1) the independent organization in which the distinctive feature is the adoption of its own principle of organization, and (2) the sect.[4] That the independent organization was chosen was almost inevitable because of the locus of the protest.

One would hardly expect that a protest group with no complaint against the organization of the mother church would turn about face and discard existing bonds for new, strange lineaments of organization. Those who protest against the formal aspects of organized religion frequently consider all constitution, hierarchy, law, discipline, priesthood, or ministry to be not only mistakes but even apostasy and sin.[5] Stating it in slightly different terms, one might say that rationality is highly correlated with more complex organization, and that experience of the mystical type is closely related with the informal, less complex type of organization.

If the transition from sect to church is conceived as a continuum,

[1] Coyle, G., *Social Process in Organized Groups*, (R. R. Smith, Inc., New York, 1930), p. 78.
[2] Ibid., p. 78.
[3] *Society*. (Rinehart & Co., 1937), p. 14.
[4] *Sociology of Religion*, (Chicago: Univ. of Chicago Press, 1944), p. 194.
[5] *Ibid.*, p. 193.

then one might say that the organization of the newly formed Orthodox Presbyterian Church enters approximately at the center of the continuum. The reason for this exceptional behavior pattern is, as stated previously, the sociological consequence of the locus of protest, an emphasis in the field of religious expression known as doctrine, and corresponding lack of emphasis on organization as fields of dispute.

But what is the picture of the structure of the group in its earliest years? By borrowing in part a structural scheme suggested by Woodward and Sutherland,[6] we can outline the major aspects, using them as rubrics under which the social processes of the Orthodox Presbyterian Church can be classified. They are: A plan for the division of responsibility, a plan for procural and initiation of new members, a plan for the standardization of behavior, and a plan for maintaining group status.

The first aspect of group structure, a plan for division of responsibility, reflects the well crystallized attitude of the new group toward formal organization. Immediately upon constituting themselves a General Assembly, four committees were established. Within the year (1936) these committees were in operation. The major interests of the group were reflected in these committees. The committee on the constitution is the embodiment of the plan for the division of authority. Within a few months this committee presented a confession of faith, a form of government, a book of discipline, and a directory for the worship of God to the General Assembly. By accepting almost in toto the constitution of its parent body, the Orthodox Presbyterian Chuch came into being with well established ideas—evidencing what Wach terms a maximum type of organization.[7] Not only setting up committees, but the substantive concerns of those committees indicate a plan for division of responsibility. Examples would be the constitution and erection of presbyteries.

The second aspect of the group structure of the new church is a plan for new members. Both the committee on Christian Education and that on Home Missions and Church Extension reflect this interest. The church shows first regard for setting up the requirements of its spiritual leaders. Ensuring doctrinal orthodoxy is consonant with the protest against doctrinal defection. And group status is more easily attained if, as was noted in the minutes of the first General Assembly, the church does not "trust the ministry to weak and ignorant men. . . ."[8] The early professionalization of leadership in the Orthodox Presbyterian Church is offered here as evidence that this religious protest group entered its life with its means to ends well stabilized. Professional leaders tending to form a bureaucracy reflect no small amount of institutionalization. It is interesting to note that the danger of professionalized leadership is not the only problem resulting from rigid requirements. There is, in addition, the concomitant problem of procuring leaders and followers when the standards are high. Per-

[6] *Introductory Sociology*, (Lippincott, 1940), p. 299.

[7] *Sociology of Religion*, (Chicago, Univ. of Chicago Press, 1944), p. 145.

[8] *Op. cit.*, p. 18.

haps this explains the dual program enumerated by the Christian Education Committee when it recommended both noetic and experiential aims. In fact, the church preaches realization and avowal of covenant blessings to the children of believers, but "saving faith" (which is experiential) to non-covenant subjects. In the words of the committee, "We must place before even the command to evangelize the lost, this prior responsibility of bringing up the children of the church in the nurture and admonition of the Lord."[9] It is this last persuasion that gives the new group a modicum of the "church" type of organization as stated by Max Weber who pointed out that, "It is (the Church's) character as a compulsory association, particularly the fact that one becomes a member . . . by birth, which distinguishes a church from a sect."[10]

The third element of group structure—a plan for the standardization of behavior—has two modes[11] which are control by sanction and control by socialization. Sanctions, which are external to the personality, take place in several areas. These areas are belief (requiring agreement with the Westminster Confession of Faith), form of government, discipline, and worship. The mode of control which is internalized by educative processes is seen in the Orthodox Presbyterian Church by the persistent efforts in supervising Sunday School material, the study of the Bible, the training of lay personnel as church workers, supporting Westminster Theological Seminary, and the formation of Christian Day schools.

A plan for maintaining group status is the fourth structural element. By striking out hard against "wickedness in high places" the dissidents are catapulted from the sequestering matrix of the parent church. The uneasy position of a new minority group upsets individual statuses. For the Orthodox Presbyterian Church it was a matter of reiterated opposition to the parent church and a reinvesting of its ministers "in good and regular standing with all rights, privileges, and active duties pertaining to lawfully ordained ministers."[12] Consequently, the familiar pattern of out-group hostility coupled with inner-group loyalty characterizes the early life of the protest group. Through the committee on Home Missions and Church Extension, the church sought to express its status when it fought a legal battle with the parent church over retention of its original name. Thus we see again that the Orthodox Presbyterian Church enters group life with definite plans for maintaining group status.

We turn now from the synchronic picture of group structure in order to view the group as it functioned from 1936 to 1946. The concept of institutionalization now becomes the major focus. Institutionalization has been defined as that social process wherein the initial aim or original ethic of a group is gradually displaced by the concern for the organization in itself. The means

[9] Minutes of 12th General Assembly of Orthodox Pres. Church, p. 44.
[10] Parsons, T., *M. Weber: Theory of Social and Economic Organization* (New York: Oxford Univ. Press, 1947), p. 157.
[11] Landis, P., *Social Control* (Chicago, Lippincott Co., 1939), p. 335.
[12] Minutes of 1st General Assembly of Pres. Church of America, 1936, p. 12.

whereby the group pursues its ends gradually occupy the group's concern more than the original ends.

This process cannot be seen by a simple extrapolation of the means of the group from the totality of its life processes, with the naive hope of watching the means or structure become incrusted, complex, spotlighted, more important, etc. Rather, the very burning issues which absorb the members of the Orthodox Presbyterian Church from day to day must be considered as the backdrop against which the persistent structural aspects become apparent. For example, the plan for the standardization of behavior as an aspect of group structure becomes increasingly more important as the strong minority bid for "eschatological freedom."

These decision situations are the dynamics of the process of institutionalization. Upon these decisions rests the process of institutionalization. In fact, the process may be accelerated, decelerated, or thwarted completely. There is no ineluctable destiny for the group once it is organized. However, the process of institutionalization cannot, therefore, be minimized. A decision making for or warring against institutionalization is made only at a cost. There arises a dilemma—a peculiarly bothersome one for religious groups. It is known as "the dilemma of the churches."

The formulation of the concepts in the dilemma of the churches is the work of many sociologists. Troeltsch, Max Weber, Von Wiese, MacIver, and Yinger have dealt with the phenomenon. The dilemma of the churches is that of choosing between two ideal types of response. They are at opposite ends of a continuum. The sect type response is that wherein the group in the struggle for power in society refuses to compromise its ethic, purpose, or value and thus withdraws. By withdrawing from society it keeps its ethic pure but loses influence, except as a critic. The church type response is that wherein the group compromises its ethic to gain influence and thus moves toward identification with society. By gaining power it has lost the strength which derives from a pure ethic. This dilemma, obviously, is not restricted to religious groups. Wherever a group is impelled by an urgent value, this dilemma will arise.

This discussion of social organization becomes meaningful, however, only when we ask what is behind the choices resulting in a church type response or a sect type response. The root of the sect or church type responses is in the dual nature of a religious group. It is both supra-social and social. The achievement of the values of a religion demands some kind of power over often recalcitrant human beings, and thus the religious expression seeks embodiment in organization. This organization may, however, defeat its original purpose by adopting methods used by secular organizations which are made necessary by the relative lack of a strong religious interest in most individuals. There is embodied in the religious institutions a manifestation of two contradictory sets of values, one clustering around the religious idea, the other centering in the secular power of the institution. Faced with the clamor of con-

flicting powers the group must attempt adjustment. And such an adjustment rides the horns of a dilemma.

The church type of response leads to identification of the group with society, with attendant support of the *status quo* of the social structure. The sect type response leads to withdrawal from society with a consequent indifference or hostility to the *status quo.* Transition from lack of support of the *status quo* to support of *status quo* is well known to sociologists as the conflict—accommodation cycle.

The process of institutionalization is seen in the transition from the sect to the church. It is well to remember that not all religious organizations begin with a sect. Some, like the Orthodox Presbyterian Church, have both sectarian and church type elements. Hence, the problem before us is to ascertain the direction of the Orthodox Presbyterian Church.

The admixture of sect and church elements provides the nuclei around which are clustered protagonists. Their role in the growing cleavage in the church highlights the sect-church dilemma. Beginning with the strife over eschatological freedom the Orthodox Presbyterian Church faced the dilemma.

Eschatological freedom was one of a triumvirate of disagreements that occurred nearly simultaneously. When the issue of Christian liberty in regards to alcoholic beverages, and the "independency" of the independent Board for Presbyterian Foreign Mission were added, there was formed a tight weld of interests. To have relaxed the general attitude toward premillenarianism could have meant inclusion of more prospective members. To have changed the constitution in regard to Christian liberty could have meant inclusion of more people favoring the separated or unwordly life. To have condoned the independency of the Mission Board could have meant inclusion of some men not wholly responsible to the Church. The dilemma was one of relaxing the standards to gain members and power, and by so doing, losing some of the purity of the original ethic. Many felt it might be the opening wedge of modernism. The majority chose to retain the standards without change. A minority of 29 ministers resigned.

Such a sect type response may have been an initial rash act of those untutored in the danger. At any rate, it is perhaps worthy of note that the next major problem that arose was handled in a much more sophisticated manner. When the opinion began to crystallize in 1939 that members of oath-bound societies should not become members of the church, the church deftly handled the matter by referring it to committees for study. Nine years later (1948) the issue was still buried in committee study.

In 1941 a vexing problem arose which seems to be the forerunner of the present cleavage in the church in which adumbrated sect and church type nuclear groups began to form. Here we see becoming explicit for the first time the actual struggle of the church for power in society. It was determined that a Committee of Nine be elected to "study the relationship of the Orthodox Presbyter-

ian Church to society in general, and to other ecclesiastical bodies in general, with a view to bringing recommendations suggesting ways and means whereby the message and methods of our church may be better implemented to meet the needs of this generation and the Orthodox Presbyterian Church may have an increasing area of influence and make a greater impact on life today."[13] Disputation arose over the best way to implement such a goal. A minority group recommended "emphasis upon the vigorous proclamation of our distinctive faith rather than upon cooperation with other churches."[14] Here we see a characteristic sect type response to the social milieu.

It would take more time than we have available to describe in detail these various eruptions and their development. We can do no more than touch the highlights. A highlight which is ancillary to the problem faced by the Committee of Nine was seen in one of the ideas which grew out of their deliberation. Some of the church leaders wanted to establish a Christian University supported by Christians throughout the land. Orthodox Presbyterian Churchmen were in the forefront of the movement. They went as far as buying an expensive estate near Philadelphia only to find too few Christians willing to support the idea. The reason given was that the board of directors tried so hard to avoid heterodoxy in their detailed Calvinistic views that they could not compel interest in the American people to bring in the necessary money. As a result of this uncompromising sect type approach, the idea never caught fire. The estate is now a white elephant.

Those making the sect type response in regard to how to deal with society soon found themselves together in a doctrinal dispute centering around a certain Dr. Clark. The rationalism into which Dr. Clark was allegedly slipping was of course an indication to those of the minority right wing—or sect type—that compromise was imminent. It did not help matters when Dr. Clark became a leader in his group for close cooperation with other evangelical churches in an ecclesiastical organization. At the close of this study in 1946 this had become the central point of the dispute. Inclusivists desiring cooperation were called "left-wingers," and those who were exclusivists were being called "right-wingers." Overtones of political ideology are also becoming apparent as the left-wingers, although largely conservative politically, have become actionists. Now we see the increasing pressure in the church to move toward the church type response, in which change is demanded.

Such polarization as seems to be in process is not near completion. There are still some members who are in flux. The lines are not as yet drawn too clearly. What are seen are syndromes. The way these latest problems are dealt with will reveal which direction the church chooses to go. Should the church type response predominate, the protest group will lose much of its original character as it becomes more institutionalized. Should the sect type response predominate, the group seems destined to live in quite

[13] Minutes of 8th General Assembly of Orthodox Pres. Church, p. 24.
[14] Minutes of 9th General Assembly of Orthodox Pres. Church, p. 32.

a bit of tension because of its highly articulated organization which precludes complete withdrawal from present entangling forces.

If the sect-church dilemma provides the dynamics of institutionalization, then the mechanics are to be seen in such accoutrements as growing structural complexity, increasing accommodation to out-groups, and a decrease in resort to charismatic authority. The dilemma of the Orthodox Presbyterian Church, whether to follow the sect type pressure group or the church type pressure group, has resulted in a cleavage. The cleavage in turn has concomitants.

The first concomitant of cleavage under discussion is structural complexity. The growing proliferation of the means or ways of proceeding of an organization has been called the process of institutionalization. It is proposed that such a phenomenon results in part from the growing attempt on the part of the group to settle the dissension. When the function of the group has added to it the problems of the sect-church dilemma, there is also an added element of structure. The evidence adduced in that area of the division of responsibility is the numerous changes in the form of government, changes in the rules of debate and decorum, and a proliferation of committees—from four in 1936 to 16 in 1946. Differentiation of structure also took place in the plan for new members as the church attempted to clarify requirements and recruitment procedures, as witness the concern of committee on oath-bound societies, and the committee on local evangelism. Whether to reach the lost first or the covenant youth of the church was the issue. By deciding to concentrate on the children of the church the work of the Christian Education committee was set up. Thus in that area of standardization of behavior there is also complexity. The budget increased from $750 in 1940 to $12,420 in 1946 for the committee on Christian Education. Its expenditure list increased in the same period from six items to seventeen. The last element of group structure, maintaining group status, takes an interesting turn. Its complexity is developed in the increased work of the committee on Home Missions and Church Extension which had a budget of $7,400 in 1936 and $58,362 in 1946. However, the focus of the committee was not on battling outside groups. Rather, emphasis on internal machinery, a preoccupation in building itself rather than opposing out-groups.

The second concomitant of cleavage is accommodation to out-groups What we see is a toleration of many out-groups. Opinions are in flux in the church, and the growing challenge to the early right-wing leadership illustrates the demand for "united action on the part of Bible believers . . . Our world and life view demands that our isolation be ended."[15] The exclusivists, with sect type response resist any change of original viewpoint, fearing modernist inroads. The inclusivists, with church type response, press for some compromise because they fear the church may become ingrown. Consequently, with dissension internalized, there is subsequent forgetting of enemy out-groups. The

[15] Minutes of 12th General Assembly of Orthodox Pres. Church, p. 65.

paradox is that by pressing for accommodation, the inclusivist group has drawn the attention of the exclusivist group to the strife in the church, with the consequent forgetting of conflict with others. The pressure for wider accommodation is seen in the inclusivist's drive for cooperation with other churches. As they put it, "We are faced with a life and death struggle which compels us to join the American Council of Christian Churches or stay on the side lines and argue among ourselves with distinct possibility of either perishing or existing as a harmless and freakish sect."[16] The social conditions which act as determinants for these sect-church dilemmas are nowhere more clearly seen. In the minority's opinion ". . . the social and moral questions of society demand united action on the part of Bible believers."[17]

Parallel with inclusivist drives for more amicable relations with some out-groups is the development of numerous committees appointed in order to keep the church functioning smoothly—an indication of the focus of the group.

Because man's religion has a social component it is subject to the social processes. Though not fully clear in the Orthodox Presbyterian Church, there is yet evident the accommodation process as a concomitant of cleavage.

A final word on the concomitants of cleavage concerns the routinization of charismatic authority. It is obvious that the prolix cleavage is an indication that the problem was not solvable by recourse to the Scriptures—a charismatic authority. The question then arises—to what authority are the two groups appealing? The answer is that both traditional and rational types of authority (to use Weber's concepts) are invoked; and, that such recourse indicates the growing routinization of charisma. The life of the church is not only dependent on the vitality of charisma; it is also dependent on the traditional and rational authority to which it now turns to settle the dispute. Ultimately the supra-social may be encrusted by the social. At present, the charismatic authority is strong, but relegated to a secondary position as the church is plagued with the dilemma. Illustration for this point is seen first in the work of the committee on Texts and Proof Texts which cautions that rational action is necessary to answer many questions left unanswered by the Scriptures. That rational action —or "light of nature"—includes such mundane social patterns as traditional authority is abundantly clear from the Clark case. This case was the crux of the sect-church dilemma as the group faced it in 1944, and the scurrying of both sides to find precedents for their views indicated the prevalence of traditional authority. The complainants referred to Hodge, Calvin, Warfield, Thornwell, Charnock, and Bavinck as reformed theologians with whom Dr. Clark was out of step. Since 1944 there has been a notable decrease in appeals to theological heroes of the reformed faith as each side issues papers which are of necessity more rational. Znaniecki, in his work entitled *The Social Role of the Man of Knowledge,* has described how dis-

[16] *Ibid.*, p. 64.
[17] *Ibid.*, p. 65.

putation among the sacred leaders involves a recourse to rational argumentation which is inimical to charismatic authority.

Conclusion of the study of the protest group leaves us with the following hypothesis: the phenomenon of institutionalization is in large part the result of decision situations in the sect-church dilemma which in turn have the unpurposed concomitants of structural complexity, accommodation to out-groups, and routinization of charisma.

SOUTHERN ILLINOIS—A CULTURAL AREA

WILLIAM J. TUDOR
Southern Illinois University, Carbondale

Introduction

In the southern 31 counties of Illinois certain economic, social, and cultural traits and complexes exist which tend to differentiate the area from the other parts of the State. Geographic factors such as soil type, climatic conditions, and topography, along with the fact that it is bounded on three sides by important rivers, give it additional distinctiveness. Also, it has what might be considered a cultural center in Southern Illinois University located at Carbondale in Jackson County. This university, being the only accredited university in the southern third of Illinois, serves as a focal point for advanced education. The 31 counties included in the analysis presented here were selected on the basis that they regularly supply students to the university and are considered by the administration of the university as being in its sphere.

Although many definitions of a cultural area have been presented, the thesis of this paper is that the area analyzed complies with the definition given by Duncan.[1] He defines a cultural area or region "as a locality characterized by the prevalence of dominant cultural traits and complexes which form a common pattern of life. Such an area must have a center, or focal point, where the concentration of the characteristics becomes relatively fixed."

The analysis is still in process. To date it has been limited in scope, for the most part, to secondary source materials. It is recognized that a complete analysis must include cultural factors that do not lend themselves to quantitative methods. Since it has not been possible to date to include these cultural factors, this paper is presented in the form of a progress report. The information here presented, incomplete though it may be, indicates the presence of cultural factors which confirm one another and consistently reveal a cultural area.

It should be pointed out that before developing programs for the correction of social and economic problems confronting given geographic areas, it is essential the culture of the area be analyzed. Areas such as the one found in the southernmost part of Illinois contain problems directly related to the culture, to the social situations, and to the economic conditions found.[2] Only by determining the interplay of these cultural elements and social and economic factors, along with the influences they exert, can a sound program for their improvement be developed.

Analysis of the Area

A number of indices are being used in the analysis to determine

[1] Duncan. O. D., "Southwest, a Cultural Area in Evolution," *Southwest Review*, Vol. 27, No. 4, Summer 1942, p. 391.

[2] Please accept the writer's opinion that the existence of problems in the area does not necessarily mean that this is a problem area. Every area has its problems.

FIG. 1.—Infant deaths per 1,000 live births, 1942-1944.

FIG. 2.—Percent of births in hospitals, 1945.

whether a cultural area exists. Ten of these indices will be presented in this paper.[3]

First, let us consider three economic factors that have a close relationship and indicate distinct differences between this area and other parts of the State. The per capita assessed valuation in the southern 31 counties was $1969 in 1945 compared to $2416 for the State as a whole. Only six counties in the area had a per capita assessed valuation above the average for Illinois. The lowest county and nine of the ten lowest counties of the State were found in the area. The average value of homes for Southern Illinois in 1940 was $1323 as compared with $3120 for the State as a whole. Only two counties, and these were different counties from the exceptions referred to in discussing the previous factor, had an average valuation of $2000 and over. The rate of dependency upon the public aid programs was high for Southern Illinois, where in January, 1946, 51.16 persons per 1000 population received assistance. This was nearly twice the rate for the State of Illinois which was 28.58 per 1000 popula-

[3] The sources used for these indices were:
a. Sixteenth Census of the U. S. Population; Second series, 1940.
b. The Illinois Hospital Survey and Plan, Illinois Department of Public Health, July 1, 1947.

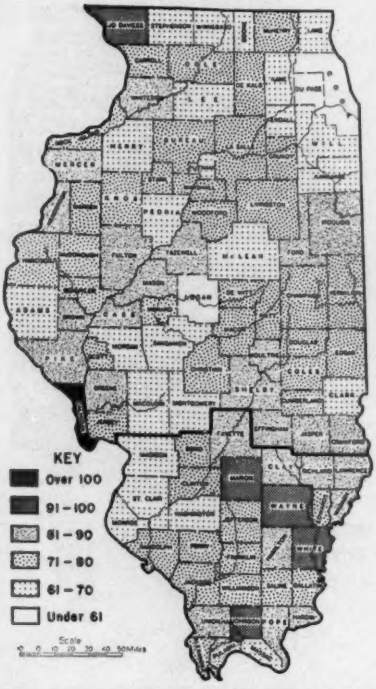


FIG. 3.—Live births per 1,000 females, 15-44 years, 1940.

FIG. 4.—Average of ten standard-of-living measures.

tion. Here again, two counties were in the lowest one-fourth of the counties of the State and neither of these two counties were among those listed as exceptions to the low status for valuation of homes or per capita assessed valuation, above.

The educational attainment of the population of the area again indicates a low level of attainment. The proportion of persons 25 years of age and over having completed six or more years of school in 1940 shows that Southern Illinois had just under 75 percent whereas the State as a whole had 81.3 percent Other indices, such as the average year of school completed by the population, show a similar pattern for the Southern Illinois area.

As might be expected, where economic conditions are relatively low the percentage of deaths occurring in hospitals in 1945 is also low. The same thing applies to the percentage of births in hospitals in 1945. A noticeable proportion of the population were unable to go to the hospital to die or to be born.

The infant death rate is also high in this area where we find a rate of 47.4 infant deaths per 1000 live births in the period of 1931-1944 compared to 33.1 for the State of Illinois (fig. 1). One interesting aspect of this is that as the per-

FIG. 5.—Total sum of ranks of five factors.

centage of births occurring in hospitals increases the infant death rate decreases (fig. 2). The live births per 1000 females 15-44 years of age in 1940 was also relatively high (fig. 3). In this instance the highest county falls outside the Southern Illinois area. With the exception of five of these 31 counties, all the counties in the area fall within the four highest ranks of counties in the State, namely, those having more than 70 live births per 1000 females, 15-44 years of age in 1940.

The average of 10 standard-of-living measures shows that the Southern Illinois area in general is below the rest of the State (fig. 4). With the exception of Calhoun County, which adjoins this area to the northwest, and may have to be considered a part of the same cultural pattern, all of the lowest counties in the State are found in the Southern Illinois area.

SUMMARY AND CONCLUSION

In order to summarize the findings to date, five factors were selected as representatives of the many factors being examined in the study (fig. 5). These were: live births per 1000 females, 15-44 years of age, in 1940; deaths per 1000 population, 1942-1944; percent of births in hospitals to total births in 1942; infant deaths per 1000 live births, 1942-1944; and the average of ten standard-of-living measures. All counties of Illinois were ranked according to each factor and the sum of these ranks computed. These sums of ranks were again used as a final basis for ranking the counties.

TABLE 1.—DISTRIBUTION OF COUNTIES ACCORDING TO SUM OF RANKS OF FIVE FACTORS

Sum of ranks	Counties of Illinois	Counties of Southern Illinois
300 and over	10	9
250-299	20	12
200-249	22	8
150-199	23	2
100-149	15	0
Under 100	12	0
Total	102	31

The counties were distributed as shown in table 1. Of the ranks of all counties, the southern area had nine of the ten lowest counties and

all but two of the thirty-one in the lowest three classes of ranks. It should be noted that a high sum of ranks indicates an unfavorable condition. In assembling the ranks to secure the over-all figures, the fertility factor was reversed since high birth rates are usually associated with rural cultural situations and with the types of factors being used to delineate in this study. The two highest ranking counties of the area were St. Clair and Madison which contain the urban center of East St. Louis and are in the metropolitan area of St. Louis.

Certain counties on the periphery, particularly Calhoun, do reflect some of the same traits as those found in the Southern Illinois area. However, until further investigation warrants a change, it seems advisable to hold to the original 31 counties. This is especially true when nonquantitative factors are considered. For example, the people of this area attach a name, "Greater Egypt," to the area and have a feeling of belonging to it. Certain word usages and political concepts seem to distinguish the area. These are in process of being analyzed and preliminary research lends weight to the present delineation.

It would seem to follow then that a cultural area exists, including the southernmost 31 counties. Only after careful analysis of the conditions, and, of course, with the prerequisite that an objective, scientific point of view be adopted, can adequate plans be developed for retaining the desirable elements of the culture and changing the undesirable.

ZOOLOGY

CHANGING FISH POPULATIONS AS AN INDEX TO POLLUTION AND SOIL EROSION†

JOHN D. BLACK
*Eastern Illinois State College, Charleston**

It is a fact well known to any student of ichthyology that there has been a profound change in the character of the fish populations of our lakes and streams within the last half century. Even the layman knows that the pan and game fishes are not as common, and the rough fishes, notably the carp, have prospered greatly in this span of years. There are numerous references to this trend in the literature, and it is not necessary to cite authors to establish this contention.

It is equally well known, in a general way, that pollution has unfavorable effects on fish life, and many states have laws prohibiting the pollution of waters based on the principle that fish are killed by pollution. Wisconsin has a law which places the penalty for pollution on a "so-much-per-fish" basis and different species are given different values. Most states have some degree of so-called legal control of pollution based on this general principle.

There is at least one brief paper (Trautman, 1939) dealing with the effect of man-made modifications upon a local fish fauna in which factors other than pollution are considered.

In spite of all this there has not, to this writer's knowledge, yet been any attempt to evaluate the degree of pollution, or of soil erosion, by a survey of the changing character of fish populations.

Hubbs (1933) and others have directed attention to the fact that pollution, from the point of view of destruction of fish life, cannot be measured by averages or other arbitrary figures, since one exceptionally unfavorable day is all that is necessary to kill desirable fish in great numbers, and the "once in a lifetime" occurrence may be exactly that so far as the fishes are concerned. It isn't necessary to kill a fish but once to make sure that it is dead.

The point being made here is that statistical averages, tabulations of dissolved oxygen, abundance of plankton, effect of pollution upon invertebrates, and all the other limnological data that have been collected regarding pollution is meaningless until it is translated into information dealing with the effects upon the fish population. The logical place to go for that information is not to limnological surveys of elaborate design, but directly to a consideration of what has actually happened to the fishes. If the other data help in understanding why the changes have taken place, well and good, but the bare fact that the changes in the fish population have occurred and are the result of pol-

†Paper presented at the 1948 Annual Meeting of the Illinois State Academy of Science.

* State Teachers College, Kirksville, Mo.

lution is the all-important and significant point which has too frequently been overlooked.

In much of the water of the Mississippi Valley, as elsewhere, there is a "carp problem." It has been this writer's privilege to work on the infamous "carp problem" of the Madison lakes in Wisconsin. The fishermen there have been greatly alarmed over the tremendous increase of the carp in the lower lakes of the Madison chain, an increase which has taken place at the obvious expense of the more desirable species, and there has been much flurry and fuss made over the situation. At the same time the people of this area have been greatly concerned over an "odor nuisance" on the Madison lakes, and this latter problem has created such public demand for some correction that a special governor's committee has studied the problem for several years. Under the capable direction of Clair Sawyer, the scientist in charge of the study, the committee has gathered an impressive mass of valuable data on this problem.

Several facts stand out from all this study in clear relief. Lake Mendota, above Madison, is clear, healthy, and highly productive from the standpoint of pan and game fishes. Although carp are present and relatively common, they have at no time become dominant in the lake, nor have they been the source of any considerable public alarm. There is, however, a sufficiently large and well established carp population in the lake which is capable of exploding into a "carp problem" at some time in the near future if domestic pollution wastes continue to be poured into Lake Mendota in increasing quantities.

Lake Monona, on the other hand, on the downstream side of the city, and for many years the direct recipient of the city's sewage waste, rapidly deteriorated as a fish-producing lake, although at one time it was considered much the better of the two lakes from the fisherman's point of view. Lakes Waubesa and Kegonsa, still farther downstream, have likewise altered in character.

For some years the state of Wisconsin has maintained rough fish removal crews on these lakes to remove the carp in an attempt to alleviate the problem, without any noticable effect. The annual harvest of the carp from the productive waters of these three lakes is actually higher than many men will admit is possible as the total standing crop. The exact figures will soon be released in a report prepared by other workers and cannot be given here.

One of the most significant developments is the observed fact that when the sewage effluent was moved downstream from Lake Monona to Lake Waubesa the carp harvest gradually began to decline in Lake Monona and the game and pan fish population began to recover.

Here, then, is an extreme case where the character and degree of domestic pollution can be measured directly in terms of changing character of the fish population. The complete reports on the Madison lakes when finally published should go far toward providing a yardstick to measure the effects of such pollution. In final analysis, as this author has long insisted, there is no "carp problem" as such, but simply a "pol-

lution problem," and when the latter is solved the balance in the fish pollution is quite likely to reestablish itself on a favorable basis.

The same so obviously holds true for the waters of the Illinois River that no comment is needed. Certainly every other factor connected with fish production and favoring the carp is better in the lower reaches of the White River in Arkansas than in the Illinois River, yet in Arkansas there is no carp problem. There are, however, flourishing fisheries for commerically valuable species as well as a considerable sports fishing development. The one thing lacking in Arkansas is sufficient pollution to spoil the water for the other fishes and leave the carp as the only species able to stand the extreme conditions. The fish population of Western Lake Erie is still another classic example of a change in fauna because of pollution.

The excellent early work of Forbes and Richardson offers a fine point of departure for comparative fish fauna studies which could easily be correlated with the degree of pollution in the various Illinois waters. It is a field of study which should be productive of many informative reports and which, if approached from the point of view I have indicated, would go far toward establishing exactly what is and what is not pollution damage.

The same approach should be made to the soil erosion problem. So far as the author is aware this has never been done, and this also in spite of the fact that fisheries, biologists, and systematic ichthyologists year after year have noted such items as "formerly abundant, now rare" in their reports about one species after another. Certainly many taxonomists are confident that the depletion of many species is more likely due to erosion and its resultant silting of streams than to any other factor or combination of factors.

The extinction of the hare-lipped sucker, *Lagochila lacera* appears to be directly correlated with the silting of its habitat streams by soil erosion. The near extinction of *Placopharynx carinatus* seems to be based on the same cause. Jordan and Gilbert (1886) reported both these species "not rare" in the White River near Eureka Springs, Arkansas. *Placopharynx* in this same report is termed "abundant" from the Ouachita and Saline Rivers near Arkadelphia and Benton, Arkansas. Jordan and Evermann (1896) reported *Placopharynx* "abundant in the larger streams, especially in the French Broad and in the Ozark region." Of *Lagochila* they reported "abundant only in the Ozark Mountains," but also listed several streams from which this species was known. No comment was made concerning its rarity in any waters.

Lagochila appears never to have been heard of again in the Ozarks. There was a lapse of some years before serious collecting was attempted in the Ozarks, and when collectors went into the area specifically after *Lagochila* and other rare Ozark fishes they did not return with a single specimen of the hare-lipped sucker. The writer has gone to considerable trouble to find specimens of *Lagochila* and *Placopharynx* in the Arkansas Ozarks but with no success. Certainly these streams have not been fished out, and save from

the damaging effects of sawmills have been noticably free of pollution. One outstanding change has occurred. The timber has been cut from the hillsides, and streams that once flowed evenly and clearly the year round have changed to up-and-down streams, nearly dried up part of the year, and swollen with mud-laden run-off torrents at other times. It seems rather obvious that these two fishes have joined the growing list of "used to be" species that once were common before man improved the countryside. Fifty years ago *Placopharynx* was so common in the Arkansas River near Fort Smith that farm boys frequently would fill a wagon bed with the fish in a short time of spearing and netting and haul them into the city to peddle out on the streets. Over-fishing might have contributed to the relatively sudden disappearance of *Placopharynx* but it seems that this sucker pretty well held its own until the white man went into Oklahoma and Kansas and plowed up the prairie to send it down to the Gulf in a yellow, boiling flood every time it rained.

In summation it is here suggested that some profitable studies could be made on the effects of pollution and soil erosion by a direct study of the changing character of the fish population, and that the fishes themselves serve as the best possible indices to the effects of these adverse conditions upon our fish fauna.

LITERATURE CITED

HUBBS, CARL L. 1933. Sewage treatment and fish life. Sewage Works Journal, Vol. 5 (no. 6): 1033-1040.

JORDAN, DAVID STARR AND BARTON W. EVERMANN. 1896-1900. The fishes of North and Middle America. Bull. U. S. Natl. Museum No. 47, in 4 parts, 3313 pp., 392 pls.

JORDAN, DAVID STARR AND CHARLES H. GILBERT, 1886. List of fishes collected in Arkansas, Indian Territory, and Texas, in September, 1884, with notes and descriptions. Proc. U. S. Nat. Museum, 1886: 1-26.

TRAUTMAN, MILTON B. 1939. The effects of man-made modifications on the fish fauna in Lord and Gordon creeks, Ohio, between 1887-1938. Ohio Jour. Sci., Vol. 39: 275-288.

A SURVEY OF THE UNIONIDAE OF THE UPPER REACHES OF THE MACKINAW RIVER

GARWOOD A. BRAUN and GEORGE I. DYKSTRA
University of Illinois, Urbana

This survey attempted to ascertain the genera and species of Unionidae currently present in the upper two-thirds of the Mackinaw River, a relatively short river of Central Illinois pursuing generally an east to west course. Its source is in the vicinity of Anchor, McLean County, and it empties into the Illinois River just south of Pekin, Tazewell County.

The survey was made during the second, third, and fourth weeks of October 1948, under conditions of low water which greatly facilitated collecting. The mussels were collected by hand and stations were examined from the headwaters to a point where the stream had become considerably larger.

Station 1 was established about five miles southeast of Anchor, and the area of search was about one quarter of a mile. The stream bed varied from light to medium gravel with occasional muddy areas; the stream being one to eight feet wide and two to fourteen inches deep, with a velocity of one-half mile per hour. No mussels were found due to seasonal variance of water depth which discouraged a consistent fish population.

A second examination (Station 2), was made three miles farther downstream. River conditions were similar to those at the first station except for increases in depth and width. Here, living thin-shelled mussels, of small size, were found in considerable abundance: *Alasmidonta calceolus* (48), *Anodontoides ferrussacianus* (15), *Micromya iris* (9), *Strophitus rugosus* (1). In the clear water, clam tracks were readily discernable, which facilitated the discovery of the mussels.

The third station was located one-half mile south of Anchor. No appreciable change in stream conditions from Station 2 was noted; however, the following additional genera and species were found: *Anodontoides ferrussacianus* (50), *Micromya iris* (25), *Strophitus rugosus* (17), and *Alasmidonta calceolus* (17). Clams appearing for the first time were *Anodonta grandis* (1), *Carunculina parva* (1), and *Lampsilis siliquoidea* (1). The last is a heavy-shelled mussel.

At the junction of the river and state route 165, immediately southwest of Colfax, the fourth station on the survey was established. In the intervening distance of approximately five miles from the station near Anchor, the river conditions had changed considerably. Primarily, there was an increase in width, averaging four to eighteen feet, while the stream bed became rocky in areas, in addition to being composed of light to medium gravel with occasional muddy regions. Live specimens of both the thin and heavy-shelled varieties were plentiful. In addition to previously lo-

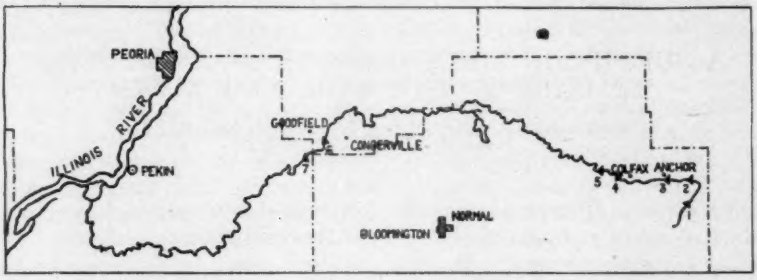


FIG. 1.—Mackinaw River and location of stations from which mussels were collected.

cated varieties, *Anodontoides ferrussacianus* (12), *Carunculina parva* (7), *Anodonta grandis* (5), *Micromya iris* (2), and *Strophitus rugosus* (2), excellent young and older living specimens of *Lasmigona complanata* (13), *Lasmigona compressa* (1) and *Leptodea fragilis* (1) were found.

Station 5 was established three miles farther downstream. River bottom conditions, except for slight increases in depth and width, were essentially similar to those of the previous station. Many of the foregoing living varieties were again found, *Anodonta grandis* (6), *Strophitus rugosus* (6), *Lasmigona complanata* (5), *Lampsilis siliquoidea* (4), *Anodontoides ferrussacianus* (3), *Micromya iris* (3), and *Lasmigona compressa* (1). However, two additional genera and species were revealed, i.e. *Amblema costata* (1) and *Fusconaia flava* (1). Prior to this station and Station 4, thin-shelled clams predominated, but at this point in the survey, now definitely showing larger stream characteristics, heavy-shelled mussels began to occur quite commonly. Van der Schalie (1936, 1938a, 1938b) mentions several of the above-listed forms as being common to middle-sized rivers.

Station 6 was located at Mackinaw Dells, two miles northwest of Congerville, Illinois, and approximately thirty-five miles from Colfax. The river bed was medium-coarse sand with considerable rocks. Possibly due to pollution of the river in this area, no living mussels were located; but considerable numbers of dead valves were found. In addition to the previously attained Unionidae, the dead shells included the succeeding genera and species: *Lampsilis ventricosa* (9), *Quadrula pustulosa* (8), *Elliptio dilatatus* (6), *Proptera alata* (5), *Quadrula quadrula* (4), *Pleurobema coccineum* (2), *Lasmigona costata* (2), *Quadrula metanevra* (1), *Alasmidonta marginata* (1), *Actinonaias carinata* (1) and *Micromya lienosa* (1). Since some of these species were not evinced by living representatives farther upstream, we have evidence that they had at sometime been established, but had been destroyed by changed river conditions. Also,

there is the possibility that ice, during spring thaws, transported the valves downstream.

Station 7 was instituted two miles southwest of Goodfield, and about four miles downstream from Mackinaw Dells. Aside from being considerably more rocky, river bottom conditions approximated those of Station 6. Living clams, previously found only as dead valves at Station 6, were located: *Lasmigona complanata* (5), *Quadrula pustulosa* (2), *Alasmidonta marginata* (1), *Lampsilis siliquoidea* (1) and *Strophitus rugosus* (1).

As a result of the survey, fourteen genera and twenty-one species of Unionidae were collected and observed.

In its course, the river does not flow through urban or industrial areas; therefore, the water is relatively free from pollution. It has been observed that freshwater mussels are among the first residents of an aquatic habitat to disappear when pollution occurs. Baker and Smith observed this previously in their research on the upper Vermilion River (Baker and Smith, 1919).

Invaluable assistance was received from Dr. Max R. Matteson and Dr. Harley J. Van Cleave of the University of Illinois.

REFERENCES

BAKER, FRANK COLLINS AND SMITH, FRANK. 1919.—A Mussell Survey of the Upper Waters of the Vermilion River with Special Reference to the Salt Fork, Trans. Ill. Acad. Sci. 12: 129-131.

VAN DER SCHALIE, HENRY. 1936—The Naiad Fauna of the St. Joseph River Drainage in Southwestern Michigan, Amer. Mid. Nat., (2) 17: 523-527.

1938a—The Naiades (Fresh-Water Mussels) of the Cahaba River in Northern Alabama, Occ. Papers Mus. Zool., Univ. Mich., No. 392: 1-29.

1938b—The Naiad Fauna of the Huron River in Southeastern Michigan, Misc. Pub. No. 40, Mus. Zool., Univ. Mich., 1-83, 12 plates.

NOTES ON THE BIOLOGY OF A COMMON GASTROTRICH OF THE CHICAGO AREA *LEPIDODERMA SQUAMATUM* (DU JARDIN)

ROBERT J. GOLDBERG
Chicago City Junior College (Herzl Branch)

Introduction

Although the Gastrotricha have been elevated to the category of a phylum since 1936 by the Committee on Nomenclature of the Zoological section of the American Association for the Advancement of Science, no other group of fresh water animals has seemingly been as greatly neglected by research workers in this country. European observers since Du Jardin (1841) have contributed most of our information concerning this group, including several comprehensive monographic treatments by such workers as Zelinka (1889), Grunspan (1910), and Remane (1936). However, with the exception of the studies of Stokes on the Gastrotrichs of New Jersey in 1887 and 1888, and those of Brunson (1947), very limited observations have been made in the United States. The author has been making collections of this group for several years for taxonomic and speciation studies to be published at a later date. This paper is a brief report on various factors of the biology and life history observations made on a single species.

The species of most general distributions in the Chicago area keys out as *Lepidoderma squamatum* in Ward's taxonomic key included in "Fresh Water Biology" by Ward and Whipple (1918), and it shows little or no variation from written descriptions of this species derived from Du Jardin's original type species. Since holotype European specimens are not available, the assumption is that this study is concerned with a geographical variant of the original European species.

Ecology and Distribution

Collections of this species were made over the summer months of the years 1946 and 1947 in the vicinity of the Chicago area from both running stream and temporary pond habitats. This species has been found repeatedly in collections from the Des Plaines River. Although no precise quantitative measurements were made, it became apparent from the habitat sources that this species requires a moderate amount of oxygen concentration in a fresh water habitat that contains very minimal amounts of organic contamination. When this organism was transferred to the laboratory and raised in an artificial medium, it required the control of pH by addition of a buffer for successful culturing.

Pure Culture Technique

Successful pure line culture technique was made possible by the isolation of single individuals through the employment of a micropipette and their introduction into glass

finger bowls containing spring water which had been conditioned by being allowed to stand for ten days and containing several rice grains which were then allowed to ferment within the water. Several of these pure line cultures were maintained for more than a year and required only the addition of a few grains of rice every three to four weeks and the replacement of water lost through evaporation. Various different types of culture media were tested, including infusions of oats, corn, peas, and hay as well as the method of cultivation by using malted milk powder described by Packard (1937). None of these were as successful as rice in maintaining cultures, and complete negative results were obtained with Packard's malted milk medium. Life history observations were made on isolated individuals grown in hanging drop preparations and in shallow depression slides.

Life History Stages

The adult animal has the body externally divided into superficial regions of head, neck, and trunk which appears to be generally characteristic of all species of fresh water Gastrotricha. Measurements made on mature living specimens show a slight variation in length between 120 to 148 mu. The width of the head varies between 20 to 25 mu, that of the neck is approximately 20 mu, and the width of the abdominal region varies between 25 to 30 mu. The body is distinctly scaled and the ventral surface bears several longitudinal rows of cilia. The head of this species is rounded anteriorly and bilobed on each lateral surface. Groups of cilia in tuft formations are found on the lateral surfaces of the head. At the posterior end the trunk forks into a pair of caudal appendages which vary in length between 23 to 26 mu. Internally, a rather heavily walled pharynx can be seen which terminates anteriorly in a mouth-like opening and posteriorly leads to the stomach-intestine. The mature form can be readily distinguished from the immature larval forms by the larger size and by the usual presence of a single large developing ovum located in the posterior third of the body.

Several hundred specimens were studied for evidence of a possible differentiation as to sex or the possibility of the existence of hermaphroditism. Histological sections were made in the search for male gonads. In all instances these observations were negative so that this organism must still be considered as reproducing only by parthenogenesis. All experimental attempts to produce a male type of organism by simulating environmental temperature variations or by the employment of sublethal temperature shocks on both egg and adult failed also in this respect.

Population clones developed from single isolated individuals which varied in size from minimal to maximal measurements showed the same variations in these characteristics as is found in any mixed population. It is thus concluded that such variations are environmentally produced and are related to some factor such as nutritional differences among individuals. Remane (1927) considers the marine Gastrotrichs as being the primitive members of this group, and the degenerate nature of *L.*

squamatum became somewhat evident with the difficulty encountered by this observer to experimentally produce genetic variations in isolated populations.

The egg of *L. squamatum* is oval in shape and has a mean length of 45 mu and a mean width of 25 mu. It appears to be covered with a chitinous-like material and bears numerous spine-like processes over the surface which appear after oviposition has occurred. The eggs are deposited on the bottom of the culture dish, usually in the vicinity of the fermenting rice media. Within the adult, the egg develops into a large cell occupying the entire posterior third of the animal. It appears as a prominent nucleus surrounded by a considerable amount of cytoplasmic material. In experimentally subjecting pure line cultures to variable constant low tempertures and to temperature shock treatment, the egg retained its viability even when maintained at approximately 4°C. Since the adults were killed off by prolonged low temperatures, it seems likely that the overwintering stage for this species in this area is in the egg.

The egg also appears to have a great deal of resistance to desiccation over extended periods of time, although this does not appear to be a necessary element in the life cycle. Three glass finger bowl cultures were allowed to dry out by evaporation at room temperatures and after a period of three weeks, the liquid was replaced by the addition of conditioned spring water. In two of the three cultures living specimens of this species were found once again after two weeks time.

Metchnikoff in 1865 described two kinds of eggs, "summer" and "winter," for the species *Chaetonotus larus,* and Remane (1926) describes a similar condition of two kinds of eggs for the species *C. persetosus.* He notes, however, that these are not to be considered as summer and winter eggs since the so-called "winter eggs" are produced throughout the year. This observer has failed to find other than a single type of egg for the species *Lepidoderma squamatum,* despite experimental attempts to produce variant types by subjecting the organism to temperatures ranging from 4°C. to 28°C. It is thus felt that experimental observations seem to preclude the question of summer and winter eggs for this species.

Summary

Collections from fresh-water ponds and streams over several seasons have indicated that the species *L. squamatum* is the most generally distributed species of Gastrotricha in the Chicago area. This organism has been successfully maintained as pure cultures in artificial infusion media, and observations were made on its life history stages. Only a single type of egg could be observed to be produced under controlled and varying experimental temperature fluctuations and this egg proved to be viable under rather prolonged extreme low temperature conditions and periods of desiccation. Thus it is suggested that the egg serves as the carrying-over stage when the organism encounters adverse environmental conditions and this may be the explanation for rather wide distribution of this species in both Eur-

ope and the United States. The egg of this species appears to be of a single type, even when tested under varying experimental conditions, and this would seem to dispel the possibility of seasonal types of eggs which have been described in the literature for other species. Adults appear under all circumstances to be unisexual and undergo true parthenogenetic reproduction. Size variation could not be shown to be a genetic constant in population clones derived from single individuals varying from minimal to maximal measurements.

LITERATURE CITED

BRUNSON, ROYAL, 1947—Unpublished Thesis at University of Michigan.

DU JARDIN, F., 1841—*Historie Naturelle des Zoophytes, Infusoires.* Paris, pp. 568-570.

GRUNSPAN, TH., 1910—*Ann. Biol. Lacustre,* 4: 211-365.

METCHNIKOFF, E., 1865—*Zetschr wiss Zool,* vol. 15: 450-463.

PACKARD, C. E., 1937—In Galtsoff *Culture Methods for Invertebrate Animals,* Ithaca 1937, pp. 176-177.

REMANE, A., 1926 — *Zool Anzeiger* 69(½): 54-56.

REMANE, A., 1927—*Zoologische jahrbucher Abt. fur systematik.* 53(⅓): 269-320.

REMANE, A., 1936—In Bronn's *Klassen U. Ordnungen des Tierreichs Leipzig.* Band 4 Abt Buch 1 Teil 2 Lfg. 2 154-297.

STOKES, A. C., 1887—*The Microscope,* 7: 1-9, 33-43.

STOKES., A. C., 1888—*The Microscope,* 7: 261-265.

WARD, H. B. AND WHIPPLE G. C., 1918—*Fresh Water Biology.*

ZELINKA, C., 1889—*Zeit f. wiss, Zool,* 49: 209-384.

GENETIC VARIATION IN POPULATIONS OF *DROSOPHILA MELANOGASTER* IN THE CHICAGO AREA

SIDNEY MITTLER
Illinois Institute of Technology, Chicago

In the summer of 1947 hundreds of *D. melanogaster* were trapped at several localities in the metropolitan area of Chicago with the purpose of determining the amount of visible mutations and second chromosome lethals in each population. With this information one would be able to analyze the genetic structure, the size of the breeding population, and determine whether a continuous breeding population was present in this particular area.

The flies were caught by baiting half-pint bottles with bananas, and placing the bottles in clumps of bushes, usually in parks or empty lots. Collections were made at three locations: one on the south side, one on the southwest side, and the other one on the north side. Each station was at least ten miles from the other two. Visible mutants were obtained by inbreeding seven F_1 pair-matings. The advantages of this method were ably stated by Spencer (1947). The lethals on the second chromosome were determined by using L/Cy as markers and inbreeding in such a manner as used by Ives (1945) in that the appearance of all Curly winged flies in the third generation would be indicative that a recessive lethal was present on one of the 2nd chromosomes of the original male parent.

The inbreeding for the 2nd chromosome lethals and the F_2 pair matings for visible recessives were done as soon as possible after the arrival of the flies in the laboratory. If they were not mated then they were transferred to a large culture bottle, and 200-400 flies were transferred monthly.

The visible mutation which was the most predominate in the Chicago area in the summer of 1947 was trident (*tri.*), a trident or streak of dark pigmentation on the thorax and scutellum. This mutant gene was found in all but one of the collections made in 1947 (see Table 2). In one collection 81.1 percent of the pair-mating which was inbred produced flies containing *tri.* The population might have gone through a bottle neck in that it was reduced to a few individuals in number. The few remaining flies contained a large number of *tri* genes. A collection at the same location two months later yielded 47.3 percent *tri.* Another mutant gene which was abundant in Drosophila populations was angle wing (a second chromosome mutant in which wings are held out at a 45° angle from the long axis of the body); this mutant gene was present in all but two of the collections.

The highly variable genetic nature of Drosophila populations in a metropolitan area is illustrated by collections No. 5 and No. 6, both from the same locality and 13 days apart.

TABLE I.—PERCENTAGE OF SECOND CHROMOSOMES TESTED THAT CONTAINED LETHALS

Stock number	Place collected	Date	Percentage of 2nd chromosomes that contain lethals	Total tested
1	4000 S. 1000 E.	8/15/47	31.1	93
2	4000 S. 1000 E.	8/22/47	4.16	106
3	4000 S. 1000 E.	8/22/47	15.2	118
5	8500 S. 2400 W.	8/29/47	34.2	120
6	8500 S. 2400 W.	9/11/47	57.1	99
10	5900 N. 1500 W.	9/18/47	5.1	83
11	4000 S. 1000 E.	10/26/47	27.4	102

TABLING II.—VISIBLE MUTATIONS OBTAINED BY INBREEDING F_1 PAIR-MATING
(In percent)

Mutation	No. 1	No. 2	No. 3	No. 5	No. 6	No. 10	No. 11
tri	41.2	81.1	....	29.3	10.6	8.6	47.3
b	12.5	....	....	....	77.7	....	5.3
w	8.6	....	....	....	....	....	....
ss	12.1	....	5.2	....	21.3	....	....
st	4.5	....	....	....	....	....	....
angle wing	8.1	7.5	5.5	....	23.2	49.2	....
net	....	....	....	....	11.4	....	....
extra vein	....	....	....	....	....	....	5.2
cmp	....	....	....	....	....	8.3	10.5
we	....	....	2.2	....	....	....	....
ma	....	....	....	....	22.1	....	....
se	....	....	....	....	11.2	....	....

In No. 5 only one mutant *tri* was re-recovered, but in No. 6 seven mutations were found. In No. 5, 34.2 percent of the 2nd chromosomes tested contained lethals and No. 6 contained 57.1 percent 2nd chromosome lethals.

The percentage of 2nd chromosomes that contained lethals varied from the time of one collection to another. One collection, No. 10 (north, side) contained 5.1 percent of lethals, and No. 6 (south side) possessed 57.1 percent second chromosome lethals (see table 1).

How can one account for the tremendous variation in the above collection in regard to visible mutants and recessive second chromosome lethals? One conclusion reached is that *Drosophila melanogaster* breeds in isolated small populations in large metropolitan areas. The small isolated groups can vary greatly from one another in that, at the time of reduction of population in the fall, different visible mutations and lethals are retained by the small groups of surviving flies. In the spring, the small groups expand rapidly in numbers and move into unoccupied areas. There must be a rapid movement or mixing of flies during the summer to account for

the daily variation in population structure at one point. Ives (1945) reported that his work with 2nd chromosome lethals in *D. melanogaster* populations in a rural area near Amherst, Mass., indicated that the flies breed in continuous populations. However, Ives (1948) found that there was a seasonal shift in lethals from summer of 1946 to summer of 1947. There is a strong possibility that *D. melanogaster* breeds in small discontinuous populations in the cities and in continuous populations in rural areas.

The presence of the *tri* in all but one population indicates that the small populations at times (probably late in the summer) expand to such proportions that there is an overflow of flies from one population to another. The populations do not remain genetically isolated from one another. The flies heterozygous for *tri* may have a selective advantage over the non-*tri* flies, and hence become fixed in the population. Reed and Reed (1948) found that a lethal inversion flourishes in the heterozygous state in the laboratory. Again this can account for the relatively high number of lethal mutations on the second chromosomes.

The study of Chicago *D. melanogaster* populations is continuing. The populations of several summers are being compared. The genetic variation of a population from one year to another year at the same location is being obtained. The weather and its influence is being correlated to the genetic fluctuation.

LITERATURE CITED

Ives, P. T., 1945—The genetic structure of American populations of *Drosophila melanogaster*. *Genetics* 30: 167-196.

Ives, P. T., 1948—Seasonal shift in frequency of lethal chromosomes in the local wild populations of *Drosophila melanogaster*. *Genetics* 33: 614.

Reed, S. C. and E. W. Reed, 1948—Natural selection in laboratory populations of Drosophila. *Evolution* 2: 176-186.

Spencer, W. P., 1947—Mutations in wild populations in Drosophila. *Advances in Genetics 1*: 359-402.

INCIDENCE OF TRYPANOSOMA INFECTION IN SMALL MAMMALS OF CHAMPAIGN COUNTY, ILLINOIS

RUSSELL E. NELSON
Department of Zoology, University of Illinois, Urbana

One might very well ask the value of a study such as is reported here. Is it of any practical value beyond the mere accumulation of information?

It is well known that the brown rat is one of man's worst pests. Every year this rodent cheats mankind out of millions of dollars worth of food. It carries lice and fleas which spread plague, typhus, and many other diseases. Any information which may help to cut down the population of rats is of great value.

A rat which is infected with a blood parasite such as *Trypanosoma lewisi* is a sick animal. Hence, it is less able to cause harm to man. Even if the parasite does not directly cause the death of the host, it must be considered pathogenic. It is robbing the host of needed energy.

Wenyon (1926) reports a method for increasing the virulence of trypanosomes by passing them rapidly through a series of rats. If, then, it were possible to infect large numbers of rats with these organisms we might have a biological method for control of rodents.

The work reported here was done in the spring and fall of 1948 between the first of April and early November. Altogether fifty-nine rodents and seven shrews were examined for blood parasites.

The animals were trapped in Sherman live traps fitted with boxes of waste to protect them from the cold. Sunflower seed and corn were used as bait. Trapping was done in an area of fifteen miles radius from Champaign, Illinois. Traps were set in ten different places throughout this area. Part of the work was done in conjunction with a population and distribution study being made by Ralph M. Wetzel in the Trelease woods and grassland, a property of the University of Illinois. The animals obtained there were marked, blood for smears obtained by clipping the tip of the tail, and the animals released. In trapping other places the animals were brought back to the laboratory for study.

The species trapped and the number of each examined are as follows:

Species	*Number examined*
Prairie vole, *Microtus ochrogaster* (Wagner)	21
Woodland deer mouse, *Peromyscus leucopus* (Fischer)	11
Prairie deer mouse, Peromyscus maniculatus (Hoy and Kennicott)	15
Common house mouse, *Mus musculus* Linnaeus	7
Common brown rat, *Ratus norvegicus* (Erxleben)	5
Short-tailed shrew, *Blarina brevicauda* (Say)	7

Identification of the above was by Mr. Wetzel.

Only two species, the brown rat and the microtus, were infected by trypanosomes. Of the 21 microtus examined, fourteen (66.6 percent) were infected. Only five rats were examined, but of these two were infected. The trypanosome found in

the rats conforms with the description of *Trypanosoma lewisi* (Kent) as given by Kudo in the 1947 edition of his Protozoology. It is therefore presumed to be *T. lewisi.*

Laveran and Pettit (1909) described a species of trypanosome found in the European field vole, *Microtus arvalis* Pallas. They proposed to call this organism *Trypanosoma microti.* Since that time several writers have recorded the occurrence of the organism in other species of microtus. Coatney (1935) found it in *Microtus pennsylvanicus.* Wood and Wood (1937) found the organism in *Microtus californicus.* Laveran and Pettit (1909) and Wenyon (1926) each give one drawing of the trypanosome. No record has been found in the literature for the occurrence of the flagellate in *Microtus ochrogaster.*

This trypanosome agrees very closely with the description of *T. microti* as given by Laveran and Pettit (1909) and by Coatney (1935) with one exception. The blepharoplast of the trypanosome found by the writer is much enlarged. In this respect there is a certain resemblance to *T. cruzi,* but when compared directly with *T. cruzi,* it is obvious that they are not the same. Two attempts were made to inoculate the organism into white laboratory rats, but without success. It is therefore concluded that the organism described here is *T. microti.*

REFERENCES

COATNEY, ROBERT G. (1935)—A note on Trypanosoma microti. Jr. Parasit. 21: 455-456.

KUDO, RICHARD R. (1947)—Protozoology. Charles C. Thomas, Publisher. p. 279. Third edition.

LAVERAN AND PETTIT (1909)—Sur un Trypanosome D'un Campagnole Microtus arvalis Pallas. Comptes Rendu des Séances et Mémoires de la Société de Biologie. 67: 798-800. One illustration.

WENYON, C. M. (1926) Protozoology. 1: 476-477. One illustration.

WOOD, F. D. AND WOOD, S. F. (1937) Occurrence of haematozoa in some California birds and mammals. Jr. Parasit. 23: 197-201.

PARASITES OF THE RANIDAE (*AMPHIBIA*). XIV*

A. C. WALTON
Knox College, Galesburg

No. 72. *Rana pipiens*, the common leopard frog of North America and standard equipment in almost every biological laboratory, has a range from Canada down through the United States east of the Rocky Mountains into Mexico. In addition to furnishing excellent material for the study of anatomy, histology, embryology, and physiology, this animal has proved a treasure-house as a source of parasites of a wide variety of types. During thirty years of use of live frogs (sent in from 18 states, 1 region in Mexico, and 2 provinces of Canada), more than fifty species of parasites have been found, about thirty of which occur fairly commonly. Interest of students has led to a search of available literature and the list has been expanded considerably.

Rana pipiens apparently serves as a host to a wide variety of parasitic protozoa, and although possibly only an accidental host to some, is a normal host to many. In addition, a few free-living forms seem to find satisfactory living conditions on the surface of the frog's skin. Tadpoles, possibly because of their feeding habits, seem to be more frequently hosts to such non-parasitic species than do the adults. Only one species of internal parasite—*Opalina larvarum*—seems to be restricted to tadpole hosts, and has been reported quite frequently from tadpoles captured in northern waters. Most of the parasites of the adults are intestinal forms, although a few are found embedded in the muscles or free in the blood stream. More than thirty species have been reported from *Rana pipiens*, of which eleven are fairly abundant. Twenty genera of protozoa are represented.

PROTOZOA

Canada:

Haemogregarina sp? of Scott, 1928. Blood.
Leptomonas ctenocephali (experimental). Intestine.
Trichomonas augusta. Intestine.
Trichomonas batrachorum. Intestine.

Mexico:

Cepedea mexicana. Intestine.

U. S. A.:

Chilomastix sp? of Wenrich, 1947. Intestine.
Endolimax ranarum. Intestine.
Euglena sp? of Hegner, 1923 (on tadpoles). Skin.
Haemogregarina sp? of Kudo, 1922. Blood.
Haptophrya michiganensis. Intestine.
Hexamita batrachorum. Intestine.
Hexamita intestinalis. Intestine.
Hexamita ovata. Intestine.
Hexamita (*Uraphagus*) sp? of Wenrich, 1935. Intestine.
Karotomorpha bufonis. Intestine.
Karotomorpha swezyi. Intestine.
Leishmania donovani (experimental). Intracellular.
Leptotheca ohlmacheri. Body cavity cysts.
Mastigamoeba hylae. Intestine.
Myxidium serotinum. Bladder.
Nyctotherus sp? of Zebrowski, 1923. Intestine.
Opalina larvarum (in tadpoles). Intestine.
Opalina obtrigonoidea. Intestine.
Opalina obtrigonoidea austricola. Intestine.
Opalina triangularis. Intestine.
(? = *O. obtrigonoidea*)
Phacus sp? of Hegner, 1922 (on tadpoles). Skin.
(? = *P. pleuronectes*)
Retortamonas dobelli. Intestine.

* Contribution from the Biological Laboratories of Knox College, No. 129.

Trepomonas sp? of Wenrich, 1947. Intestine.
Trichomitus parvus. Intestine.
Trichomonas augusta. Intestine.
Trichomonas batrachorum. Intestine.
Trimitus parvus. Intestine.
Trypanosoma rotatorium. Blood.
Trypanosoma sp? of Drbohlav, 1929. Blood.
Trypanosoma sp? of Nigrelli, 1945. Blood.

Among the Nematodes, about twenty species have been recorded, of which ten are fairly common. Five species of larval forms have been reported, of which one, *Icosiella* sp., is quite common as an encysted form in the body cavity and in the superficial body muscles. The species *Pharyngodon batrachiensis* becomes adult in the tadpole. Fourteen genera are reported.

NEMATODA

Canada:

Cosmocercoides dukae. Rectum.

Mexico:

Foleyellides striatus. Peritoneum (larvae in blood).

U.S.A.:

**Agamascaris odontocephala*. Liver and stomach cysts.
Camallanus microcephalus. Intestine.
Camallanus pipientis. Intestine.
Cosmocercoides dukae. Intestine.
**Eustrongylides ignotus*. Peritoneal cysts.
**"Filaria"* sp? of Leidy, 1852. Intestinal cysts.
Foleyella americana. Mesenteric cysts (larvae in blood).
**Icosiella quadrituberculata*. Muscle cysts.
Oswaldocruzia pipiens,. Intestine.
Oswaldocruzia subauricularis. Intestine.
Oswaldocruzia waltoni. Intestine.
Oxysomatium americana. Rectum.
Oxysomatium georgianum. Rectum.
Oxysomatium longicaudata. Rectum.
Pharyngodon armatus (female only). Intestine.
Pharyngodon batrachiensis (female only), (in tadpoles). Intestine.
**Physaloptera* sp? larva of Morgan, 1941. Stomach cysts.
Rhabdias ranae. Lungs.

The Trematodes are the most abundant and best known group of parasitic worms found in *Rana pipiens*. Sixteen species from eight genera are reported from Canada. Three are larval forms; the adult of only one of these is known. Although the frog may serve as an intermediate host in the life cycle of many flukes, few instances of such intermediate stages have been reported from Canadian examples of *pipiens*. Only seven species from five different genera have been reported from Mexican hosts; all of these apparently finding the frog as their definitive host. Among the flukes reported from the United States, thirty-five species from sixteen genera are recorded from *R. pipiens*. Sixteen of these species are fairly common. Possibly because of a greater number of observers, more of the trematode parasites of the tadpole are reported; at least eleven species have been recorded. Of these at least two become sexually mature in the adult frog. The others (where their life cycle is known) reach maturity in reptiles, birds, or mammals. For a number of parasites life cycles are not as yet completely known so that the ultimate adult and its host cannot be recorded.

TREMATODA

Canada:

Cephalogonimus retusus. Intestine.
**Cercaria vesiculosa*. Encyst in throat muscles.
**Distoma nitidum*. Stomach cysts.
Glypthelmins quieta. Intestine.
Gorgodera amplicava. Bladder.
Gorgodera cygnoides. Bladder.
Gorgoderina attenuata. Bladder.
Gorgoderina simplex. Bladder.
Gorgoderina translucida. Bladder.
Haematoloechus breviplexus. Lungs.
Haematoloechus medioplexus. Lungs.
Haematoloechus similiplexus. Lungs.
Haematoloechus variegatus. Lungs.
**Lechriorchis primus* (in tadpoles). Intestine.
Manodistomum occultum. Intestine and muscle cysts.
Megalodiscus temperatus. Intestine.

* Denotes larval forms.

Mexico:

Cephalogonimus americanus. Intestine.
Glypthelmins californiensis. Intestine.
Gorgoderina attenuata. Bladder.
Haematoloechus macrorchis. Lungs.
Haematoloechus medioplexus. Lungs.
Haematoloechus varioplexus. Lungs.
Halipegus lermensis (?=*H. occidualis*). Eustachian tubes.

U.S.A.:

**Alaria intermedia* (also in tadpoles). Muscle and kidney tissue.
**Alaria marcianae* n. comb. (=*Cercaria marcianae* LaRue, 1917) (in tadpoles). Muscle.
**Alaria micradena* n. comb. (=*Cercaria micradena* Cort and Brackett, 1938) (in tadpoles). Nerve cord.
**Alaria mustelae* (also in tadpoles). Muscle tissue.
Alassostoma parvum. Rectum.
**Apharyngostrigea pipientis* (in tadpoles). Intestine.
Cephalogonimus retusus. Intestine.
**Cercaria elodes* (enters tadpole). Notochord.
**Clinostomum complanatum.* Muscles.
**Diplostomulum vegrandis* (in tadpoles). Muscles.
**Diplostomum flexicaudum* (in tadpoles). Eye and muscle tissue.
**Distoma nitidum.* Stomach cysts.
*Distome metacercariae of Stabler and Pennypacker, 1939. Liver cysts.
**Euryhelmis monorchis* (also in tadpoles). Subcutaneous tissue.
**Eruyhelmis squamula* (also in tadpoles) (probably *E. monorchis*. *E. squamula* is the European form). Subcutaneous tissue.
Glypthelmins quieta. Intestine.
Glypthelmins subtropica. Intestine.
Gorgodera amplicava. Bladder.
Gorgodera cygnoides. Bladder.
Gorgodera minima. Bladder.
Gorgoderina attenuata. Bladder.
Haematoloechus coloradensis. Lungs.
Haematoloechus complexus. Lungs.
Haematoloechus longiplexus. Lungs.
Haematoloechus medioplexus. Lungs.
Haematoloechus similiplexus. Lungs.
Haematoloechus variegatus. Lungs.
Halipegus eccentricus (also in tadpoles). Eustachian tubes.
Halipegus occidualis. Mouth and ears.
**Lechriorchis primus* (in tadpoles). Mouth and intestine.
**Lechriorchis tygarti* (in tadpoles). Mouth and intestine.
Loxogenes arcanum. Visceral cysts and intestine.
Megalodiscus temperatus (metacercariae and adults in tadpoles and adult frogs). Metacercariae in skin, adults in intestine.
Monostoma ornatum. Body cavity.
**Zeugorchis erinus* (in tadpoles). Intestine

* Denotes larval forms.

Alaria marcianae and *Alaria microdena* are presented as new combinations inasmuch as the metacercariae of these forms from the frog have been experimentally raised (particularly *A. microdena*) in pigeons and seem to belong to the genus *Alaria*. The original reports of these experiments pointed out the proper position of the metacercariae but did not make the combinations indicated.

Members of the Cestoda are not common in *Rana pipiens* but a few specimens of *Cylindrotaenia* are found each year in the frogs collected in the field. *Cylindrotaenia* (2 species) and *Nematotaenia dispar* become adult in the frog, although the record for *N. dispar* (a European form) is possibly a misidentification of a *Cylindrotaenia* species. Larval forms of *Ophiotaenia perspicua* have been reported from tadpoles, and one record of this form as an adult in adult frogs has been listed. Unidentified larval tapeworms are frequently present in adult frogs, but identification is difficult and seldom attempted.

CESTODA

Canada:

?*Nematotaenia dispar.* Intestine.

U. S. A.:

Cylindrotaenia americana. Intestine.
Cylindrotaenia quardijugosa. Intestine.
**Ophiotaenia perspicua* (also in tadpoles). Liver of tadpoles.
Proteocephalidae of Fortner, 1923. In cysts.

Two leeches—*Haementeria montifera* and *Macrobdella decora*—have been taken from the surface of adult frogs collected at various stations in the United States.

One larval mite—*Hannemania penetrans*—has been recorded several times from specimens of *R. pipiens* caught in the southern United States.

At least six species of mosquitoes are known to feed on the blood of the adult frog, and several have been shown to be the vectors of microfilariae of at least three species of *Foleyella*, although *F. americana* is the only microfilariid definitely recognized from *R. pipiens*.

DIPTERA

Aedes aegypti.
Aedes atropalpus.
Culex apicalis.
Culex fatigans.
Culex pipiens.
Culex quinquefasciatus.

Probably the surfaces of both tadpoles and adults carry a rich bacterial flora, but only three species of internal parasites are known . One, *Proteus hydrophilus*, is the case of "red-leg disease" which so frequently plagues the aquarium stock of our laboratories. Another is an intestinal form indistinguishable from *Eschreichia coli*. The third is an acid-fast form—*Mycobacterium ranae*—although it is questionable whether tuberculosis is a "white plague" among the Amphibia. A number of forms isolated from fish and reptiles have been grown successfully in Amphibia. A more thorough study would undoubtedly increase our knowledge of the parasitic flora of Amphibia greatly.

BACTERIA

U. S. A.:
Escherichia coli. Intestine.
Mycobacterium marinum (experimental). Tissues.
Mycobacterium piscium (exp.). Tissues.
Mycobacterium ranae. Tissues.
Mycobacterium thamnopheos (exp. in adults and tadpoles). Tissues.
Proteus hydrophilus. Muscle tissue.
Serratia anolium (exp.). Intestine.

The fish mold *Saprolegnia parasitica* (Oömycetes) frequently attacks frogs kept in the laboratory aquarium.

At least two species of protozoans, four of nematodes, five of trematodes, and possibly one of tapeworms can be expected as parasites of almost every batch of *Rana pipiens* used in the laboratory, particularly if they were collected from the field and not raised commercially. In the latter case parasite collecting is usually poor. It adds interest, and possibly information, if students are encouraged to look for evidences of parasitism as well as to perform the usual laboratory exercises. Preserved as well as live material can be used, but one seldom finds other than nematodes, trematodes, and tapeworms in preserved frogs.

COLLEGIATE SECTION

CERTAIN FACTORS WHICH INFLUENCE ACTIVATION OF THE HEXACANTH EMBRYO OF THE FOWL TAPEWORM *RAILLIETINA CESTICILLUS*[1]

W. MALCOLM REID, SHIRLEY JEAN NICE, AND RHODA COOPER McINTYRE
Monmouth College, Monmouth

While carrying out life history studies on the fowl tapeworm, *Raillietina cesticillus*, great variability was noted in the number of active six-hooked embryos found in different gravid proglottids collected from the feces of infected fowls. Proglottids, which are shed from the terminal portion of adult tapeworms, contain from 150 to 300 of these onchospheres or hexacanth embryos. In some preparations, made by teasing apart proglottids, all embryos remained quiescent, but in other preparations most of the embryos showed the remarkable breast-stroke-like activity which is typical of embryos in this stage of tapeworm life history.

Although the movements of the hexacanth embryos have been induced frequently in other species, (*Taenia taeniaeformis* by Bullock, Dunning, and Curtis 1934, *Taenia saginata* by Penfold, Penfold and Phillips 1937, *Dipylidium canium* by Venard 1938, and *Bertiella studeri* by Stunkard 1940) spontaneous hatching does not normally occur unless these larvae are first acted upon by enzymes or pressure. In *Raillietina cesticillus* the violent swinging action of the six hooks may result in rupture of both the embryophore and the outer uterine shell, thus freeing the embryo from surrounding membranes. The freed embryo normally works its way through the gut wall of a suitable species of beetle (Reid, Ackert, and Case, 1938). Within two to three weeks the onchosphere metamorphoses into a cysticercoid. If the beetle containing fully developed cysticercoids is eaten by a chicken, the freed larvae attach to the gut wall and grow to adult tapeworms.

A study of the factors inducing motility of the embryos was carried out for two reasons. First, an understanding of factors inducing motility would contribute to the knowledge of the life history of this organism and might help to explain the irregular infectivity of beetles under laboratory conditions. During attempts to produce cysticercoids for studies of the pathology or for treatment of this species, a low percentage of infestation has sometimes been encountered. A second reason for this study was to further enhance the use of these embryos for teaching purposes. Due to their large size and the transparent covering membranes, they make excellent demonstrations of this larval stage. However, inability to induce

[1] Portions of this study were carried out at the Marine Biological Laboratory, Woods Hole, Massachusetts, aided by funds made available through an American Association for the Advancement of Science grant awarded by the Illinois State Academy of Science.

movement of the larvae has at times made them less effective.

A systematic study of the effects of (1) osmotic pressure changes, (2) pH concentration, and (3) temperature changes is reported upon in the present study.

Materials and Methods

Fowls were infected and proglottids were collected, according to methods described by Reid (1942). The freshly passed gravid proglottids were stored in fluids or kept moist on filter paper in covered Stender dishes before the count was made. To count the active or inactive onchospheres the proglottid was teased apart, placed in fluid on a glass slide, and covered with a cover glass. The slide was then sealed with Vaseline to prevent evaporation. The first 100 embryos were counted with the aid of a mechanical stage and classified according to the three categories: (1) living and motile; (2) living and non-motile; and (3) dead. If an embryo showed either active movements which might result in hatching or only slow lazy movements, it was classified as motile. Dead embryos could be distinguished by clouding of the normal hyaline protoplasm and disorientation of the hooks. Since considerable variability was found in the amount of motility, in later studies each proglottid was cut in half with one half serving as a control while the other half received the experimental treatment.

Effect of Osmotic Concentration Upon the Embryo

Numerous comparisons were made between the motility of onchospheres in one percent saline solution and those maintained in distilled water or two percent saline solution. No marked increase in motility was induced by any of these solutions. However, numerous embryos died after 30 minutes of exposure to distilled water. In a representative case, 90 percent of the embryos were living but non-motile after five minutes exposure and ten percent were dead. After 30 minutes, 47 percent of these same embryos were living but non-motile and 53 percent were dead. Two percent saline also had a deleterious effect upon the embryos, but it was not as rapid. In a typical trial, eight percent of the embryos were dead after five minutes, nine percent after 30 minutes, and 62 percent were dead after one hour. Embryos maintained in one percent sodium chloride were affected little, if at all, by the treatment. In a count, two percent of the onchospheres were dead after five minutes exposure and three percent after 30 minutes. This study showed that of the solutions tested, one percent saline is the optimum osmotic concentration in which to store the embryos, but that osmotic changes do not induce motility.

Effects of pH upon the Embryo

Since embryos are subjected to pH changes in the gut of the host, the sensitivity of embryos to three different solutions was tested. Using a one percent sodium chloride solution buffered to a pH of 3.6 by means of a 0.2M acetate buffer, no motility was induced in the embryos, but 64 percent were dead after five minutes exposure. All were dead at the end of seventeen minutes. One percent

saline solution buffered to a pH of 8.0 or to a pH of 6.0 by means of phosphate buffer induced no motility, but exposure for 30 minutes did not kill the embryos. It is concluded that a change in pH is not the factor which results in embryo activation.

Effects of Temperature upon the Onchosphere

Preliminary tests indicated that an increase from room temperature (21±3°C) to 37°C did not induce motility, but possibly increased the mortality rate on embryos exposed for two hours. However, a decrease from room temperature to 6-7°C for a few hours not only induced marked increase in motility, but fewer embryos died. A more thorough study of the effects of lowered temperature carried out by one of us (Nice, 1949) definitely established the effects of exposure to cold in inducing motility. By counting 100 embryos from each of ten half-proglottids which had been stored at 1°C for eighteen hours, an average of 78.7 (range 56-91) embryos were found active in each half-proglottid. In the other half-proglottids which were used as controls and stored at 21±3°C for eighteen hours, only 0.1 percent of the embryos were motile, while 96 percent were living but non-motile. None of the embryos stored in the cold were dead, but 3.9 percent of those kept at room temperature died.

Discussion

The cold-induced activity of these onchospheres may have adaptive significance in the life history of the parasite. Successful infection of the secondary host depends upon penetration of the gut wall of the beetle through activity of the embryo. Onchospheres in this species seldom live more than a day unless the temperature is cool. It has been shown by Wetzel (1934) and confirmed by Reid, Ackert, and Case (1938) that the proglottids of *Raillietina cesticillus* are shed in larger numbers late in the afternoon. Many of the beetle hosts are nocturnal in their feeding habits so that proglottids shed late in the day are eaten during the following night when a natural temperature drop occurs. For natural infections the nocturnal temperature could not drop as low as the 1 C° used in the experimental study, since the beetles themselves would be inactive at that temperature. However, the greatest numbers of onchospheres are consumed during that period when the temperature is lowest. Lack of temperature control after collecting proglottids for laboratory infections may account for some of the variability in infestation which has been encountered by various workers.

Summary

1. Decrease from room temperature (21±3 C°) to 1 C° induced activity in 78.7 percent of 1,000 embryos as compared to 0.1 percent motility found in 1,000 controls maintained at room temperature.

2. No other factors studied induced motility. A pH concentration of 3.6, distilled water, 2 percent sodium chloride solutions, and maintaining the embryos at room temperature or above increased the mortality rate of embryos, but pH ranges of 6.0 and 8.0 and one percent saline did not hasten death of the embryos.

REFERENCES

BULLOCK, F. D., W. F. DUNNING, AND M. R. CURTIS, 1934—Observations on the digestion of the shells of the eggs of *Taenia taeniaeformis*. Amer. Jour. Cancer 20(2): 390-397.

NICE, S. J., 1949—Improved methods of activating tapeworm embryos. Bios 20(2). (In press).

PENFOLD, W. J., H. BOYD PENFOLD, MARY PHILLIPS, 1937—Artificial hatching of *Taenia saginata* OVA. Med. Jour. Aus. (1937): 1039.

REID, W. M., 1942—The removal of the fowl tapeworm *Raillietina cesticillus* by short periods of starvation. Poultry Sci. 21(3): 220-229.

———, J. E. ACKERT, A. A. CASE, 1938—Studies on the life history and biology of the fowl tapeworm *Raillietina cesticillus* (Molin). Amer. Micros. Soc., Trans. 57: 65-76.

STUNKARD, H. W., 1940—The morphology and life history of the cestode, *Bertiella studeri*. Amer. Jour. Trop. Med. 20(2): 305-333.

VENARD, C. E., 1938—Morphology, bionomics, and taxonomy of the cestode, *Dipylidium caninum*. N. Y. Acad. Sci., Annals 37: 273-328.

WETZEL, R., 1934—Untersuchungen über den Entwicklungskreis des Hühnerbandwürmes *Raillietina cesticillus* (Molin, 1858). Arch. wiss. u. prakt. Tierheilk. 68(4): 221-233.

MEMORIALS

CHARLES TOBIAS KNIPP

1869-1948

Charles Tobias Knipp was born on August 13, 1869 in Napoleon, Ohio. He attended Indiana University where he was graduated in 1894 and took his master's degree in 1896. He married Frances Winona Krause on June 25, 1896. He then served for two years as instructor in physics at Indiana University. In 1898-1900 he held the President White fellowship at Cornell University and there received his Ph.D. in physics in 1900. He then returned to Indiana University where he served for three years as Assistant Professor of Physics. In 1903 he joined the department of physics at the University of Illinois in which he served continuously until his retirement in 1937, with the successive ranks of Assistant Professor, Associate Professor, and Professor of Experimental Electricity. During the recent war he served as Visiting Professor of Physics at Rollins College.

Dr. Knipp was keenly interested in experimentation and became extraordinarily skillfull in the techniques of manipulation. His 100 publications are predominantly reports of inventions or improvements in experimental methods or devices, or scientific conclusions which resulted fairly directly from such improvements. This inclination towards manipulation, combined with a considerable talent for showmanship, lead him to devote a good deal of attention to developing the art of lecture demonstration. His reputation as an interesting demonstrator spread far outside his classes, and he was besieged with invitations from educational and civic groups which he accepted as frequently as time permitted. This was his way of spreading a public appreciation of physics. A number of his inventions, notably the Knipp alpha-ray track apparatus, several discharge tubes, a nitrogen after-glow tube and the Knipp singing tube are widely used by physicists and constitute permanent contributions to the art of demonstration.

His scientific contributions clearly show the influence of his two sabbatical years, 1910-1911 and 1926-1927, at the Cavendish Laboratory in Cambridge, England, where he was associated with J. J. Thomson and Rutherford and whence he returned to this country to carry on the Cavendish tradition of research in conduction through gases and in radioactivity. One outcome of this work was a patent, jointly with the late Professor H. A. Brown, on an Alkali Vapor Detector Tube which was widely used and returned considerable royalties to the University.

Professor Knipp was responsible for the development of the course in electrical and magnetic measurements, known as Physics 44, and himself devised many of the experiments. He was also responsible for the functional design of the present Physics Laboratory which was completed in 1909.

He was a fellow of the American Physical Society and of the Ameri-

can Association for the Advancement of Science, a member of the American Optical Society, the American Institute of Electrical Engineers, the Society for the Promotion of Engineering Education, Sigma Xi, Phi Beta Kappa, the Indiana Academy of Science, and the Illinois Academy of Science, of which he was vice president in 1920 and president in 1921. His name was starred in the first and subsequent editions of American Men of Science. He was an active member of the committee on physics of the Century of Progress Exposition in Chicago in 1933.

Professor Knipp always took an active interest in community and university affairs. He served on the Urbana City Council from 1935 to 1943 and on several of its committees. He was secretary of the Board of Trustees of the McKinley Presbyterian Foundation.

In addition to having initiated many graduate and undergraduate students into the art of experimental and manipulative physics, Dr. Knipp always took a keen interest in their personal affairs, and he and Mrs. Knipp made their home a center of social life for many students.

Professor Knipp died on July 6, 1948. Surviving him are a son, Julian, Professor of Physics at Iowa State College; three daughters, Mrs. Max Shipley, Mrs. George Hill, a well known etcher, and Mrs. Paul Grote; a brother, Julius; a sister, Mrs. Illian Atkinson, and five grandchildren. Mrs. Knipp's death had preceded his by seven years.

Professor Knipp was an ingenious experimenter, a skillfull demonstrator, an enthusiastic educator of young men, a public spirited citizen, and a valued friend. His loss will be keenly felt in the world of physics and in the community.

(Signed) F. W. LOOMIS
H. H. JORDAN
F. B. SEELY

MARGARET ENGSTROM
1908-1948

Miss Margaret Elizabeth Engstrom, science teacher in Moline, Illinois, passed away on September 26, 1948. She was only 40 when cancer cut short her singularly rich and beautiful life.

Miss Engstrom received her early schooling in Moline. In 1927, when she entered Augustana College in nearby Rock Island, she was already an ardent student of the out-of-doors. In college, geology opened up a new world to her, kindling an interest which never became dimmed. As a college student she worked her way, and at various times served as laboratory instructor in both biology and geology. Handiwork that showed her skill as a preparator may still be seen in the college laboratories; and none of her science teachers is likely to forget the clarity and orderliness of her notebooks or the exquisite artistry of her pen and ink drawings. By extending her studies beyond the regular four years, she completed graduation requirements in both biology and geology, and became the first woman to major in the new department of geology. Subsequently she took postgraduate summer courses in botany at the University of Chicago.

At graduation in 1931, Miss Engstrom was appointed to the teaching staff of John Deere Junior High School, in Moline, her home city. Here she continued for seventeen years, the remainder of her life. During one year (1946-1947) she also taught geology at Moline Community College.

Miss Engstrom was a born teacher. One can hardly imagine her in any other capacity. For all her shyness and modest bearing, she was completely at ease with young people, who in turn understood and loved her. There was nothing superficial about Miss Engstrom's passion for nature; it glowed with clear, quiet intensity, and because it was so genuine it was contagious. Her thoughtful nature had deep undercurrents which she seldom expressed, either in words or writing, but of which all associates became aware. To these, therefore, it was not wholly a surprise when, after her death, a collection of poems of rare beauty came to light which she had written but never shown to anyone.

At John Deere Junior High School, an active Science Club came into being under Miss Engstrom's guidance. Through the years it developed many projects, including an excellent teaching museum; and its members accompanied Miss Engstrom every spring to the meetings of the Illinois Junior Academy of Science, where their exhibits regularly won high awards. In the Tri-

Cities, Miss Engstrom and her unfailing coterie of 'teen age boys and girls—often more than a score in number—were a familiar sight at every worth-while program or lecture relating to science, travel, or the out-of-doors.

Week-ends were devoted to field trips, and this was the activity which the members of the Science Club, and Miss Engstrom herself, enjoyed most of all. Probably no one knew the wooded ravines and upland prairies along this part of the Mississippi Valley better than this little teacher, who would set out with her devoted following, after school hours and on Saturdays, rain or shine. The field trips netted many fine fossils and other specimens for the museum. What was far more important, they left most of the students with a lifelong enthusiasm for natural history and the earth sciences.

Inevitably, from Miss Engstrom's Science Club came a steady stream of students who went on to higher studies in the various fields of science. At Augustana College, the Alma Mater to which Miss Engstrom was always loyal, year after year freshmen students—potential majors in biology or geology—presented themselves for registration with the simple but all-sufficient explanation that there were "Miss Engstrom's boys," or girls, as the case might be. They were always welcome.

In later years Miss Engstrom became an enthusiastic traveler, and during summer vacations visited Canada, Alaska, and most parts of this country. She returned repeatedly to her favorite western National Parks, her car filled with young people and their bulging bedrolls. In the spring of 1948 she became ill, but after treatments was again able to go west in the summer, to Wyoming. In September she participated in the opening conferences of the junior high school staff, but only for one day. The dread disease had recurred, and this time it ran a swift and fatal course.

Fifty active and alumni members of the Science Club have now founded "The Margaret Engstrom Society," which is pledged to continue Miss Engstrom's work and keep her ideals bright at John Deere Junior High School, by the establishment of various types of living memorials.

Miss Engstrom's home community will long recall her as a unique personality and one of the most gifted teachers in its history—and who would attempt to measure the significance of such a teacher to any community? Unnumbered men and women, her former students, hold Miss Engstrom in grateful remembrance. Many would thank her, if they could, because her gentle yet profound influence gave direction to their lives.

FRITIOF FRYXELL

ACADEMY BUSINESS

SECRETARY'S REPORT OF THE BUSINESS OF THE ILLINOIS STATE ACADEMY OF SCIENCE FOR THE YEAR MAY 8, 1948 TO MAY 7, 1949

Compiled by HURST H. SHOEMAKER,
Secretary

The 42nd Annual Meeting of the academy was held at Knox College in Galesburg on May 6 and 7, 1949. There were 103 papers presented in the nine senior and two collegiate sections to an attendance of about 675 persons. The annual banquet speaker on Friday evening was Dean Willard B. Spalding of the College of Education of the University of Illinois who spoke on "Training for Tomorrow's Schools." The 18 Illinois science talent search winners came to the platform to be introduced. The college or university to which each had won a scholarship was announced. Further carrying out the theme of science education was the address on Friday morning by C. W. Sanford, Director, Illinois Secondary School Curriculum Program, University of Illinois, who spoke on, "The Who in the High School Science Program." This theme was chosen in an effort to stimulate interest in the Psychology and Education section and to invite High School teachers to greater participation in the Academy of Science.

In regard to participation in Academy activities, the secretary has noted an indifference to the Academy on the part of some of our more prominent scientists. One of the reasons offered for this feeling is that publication in the *Transactions* does not carry the prestige of some of the national journals. One of the greatest values of the Academy is the opportunity offered to young scientists in getting experience in presenting their work at scientific meetings and in preparing it for publication. The privilege of encouraging these younger scientists is a service we should not lose sight of in deciding the value of the Academy. The nationally known scientists should consider their obligation also to meet with other scientists of the State and share with them their scientific advantages not possible to all, thus raising the general quality of Illinois science.

1. COUNCIL MEETINGS

The usual four council meetings were held during the year. President Paton presided over the first meeting in Benton May 8, 1948. Invitations for the 1949 meeting were discussed and the secretary was instructed to investigate them further and obtain formal invitations to be considered at the second council meeting. A policy regarding the release of back numbers of *Transactions* was presented and approved.

At the second meeting in Urbana October 9, 1948, the invitation to meet in Galesburg was accepted. After the duties of the committees were outlined by President Paton, reports were heard from the committee chairmen present. The Psychology and Education Chairman recommended that the section be dropped because of lack of interest. The council pointed out the Academy's responsibility to the science teachers of the state and decided to feature science education at the annual meeting in order to stimulate interest in this section. The officers of the Junior Academy met with the council until after arrangements for the annual meeting had been discussed. Mr. Porter presented a detailed report for the Junior Academy. As sufficient time did not remain to discuss the financial problem in relation to publishing the *Transactions*, the meeting as a whole was adjourned. In the afternoon a smaller group met to discuss this matter and estimated an amount needed for printing during the next biennium.

President Paton presided at the third council meeting January 15, 1949. Copies of the budget, the constitution, and forms to be used in the solicitation of papers for the annual meeting were distributed. A plan was approved for inter-office communication between the secretary, the treasurer, and the museum for keeping a better record of the changes in membership. After a discussion of the limitation to the length of

papers to be presented in the *Transactions*, the council felt that though eight printed pages should ordinarily be the limit, the acceptance of unusual longer papers should be left to the judgment of the editorial committee until further action.

Section chairmen gave progress reports on their plans for the annual meeting. Dr. Mills reported that conservation of the small natural areas had been the primary interest of his committee. He introduced George B. Fell, who had been doing a great deal of work on these areas, and who gave a detailed report of his activities. The council added Mr. Fell to the conservation committee and authorized him to represent the Academy at discussions in Springfield regarding the conservation of small areas.

The fourth meeting followed the council dinner on May 6 at Galesburg. There were 28 present with President Paton presiding. There were reports from the committees on budget, affiliation, conservation, and science talent search. Mr. Porter gave a report for the Junior Academy and indicated the desires of such companies as General Motors, General Electric, and Westinghouse to present exhibits at future annual meetings. Dr. Tehon reported for the publications committee and gave a brief report for the editor in her absence. Both Augustana College at Rock Island and the University of Illinois at Navy Pier extended cordial invitations to have the annual meeting of the Academy there in 1950.

PROGRESS REPORT ON THE ILLINOIS NATURAL AREA PRESERVATION PLAN

At the last annual meeting of the Academy, Dr. Mills presented a proposal for establishing a system of nature preserves in the State. The following resolution was passed at that meeting:

"Whereas, the State of Illinois is known to contain small natural areas distinct and precious by reason of their unique ecological features and rare species of plants and animals, and

Whereas, these areas are too small for inclusion in the State Park System as now visualized, and

Whereas, these areas are threatened with impairment or destruction by the inroads of industry, agriculture, or other developments, therefore:

Be it resolved, that the Council of the Illinois Academy of Science refer to the proper committee of the Academy the question of (1) finding some administrative state agency interested in the acquisition of such widely separated areas, (2) proposing some way of administering and protecting them, and (3) devising some method of selecting deserving sites, formulating specifications which the sites should meet, and assuring that the purpose for which the sites are set aside be actually preserved."

This report summarizes the work which has been done on the proposal since that time.

Publicity activities

(1) A circular letter was mimeographed on Nov. 29, 1948, and sent to about 500 persons including many Academy members.

(2) An outline of the main points of the proposal was compiled in February, 1949, on the basis of correspondence and consultation with a number of persons. Several hundred copies have been distributed. (See proposal for a System of State Natural Area Preserves.)

(3) Other organizations interested in conservation in Illinois have been contacted. These include the Conservation Council, Ecologists Union, Friends of Our Native Landscape, Illinois Chapter of Wildflower Preservation Society, Nature Study Society of Rockford, and others.

(4) Various State officials and agencies concerned with conservation have been contacted regarding the proposal.

Information accumulated

(1) A list of Illinois natural areas in need of preservation has been begun. To date the list includes 53 areas, but is incomplete in regard to areas cited and details concerning them.

(2) Information has been accumulated concerning natural area preservation activities elsewhere. Projects similar to the Illinois plan have been begun in Wisconsin and Michigan. The Iowa Academy of Science has sponsored a program to preserve prairie tracts in that State. The Society of American Foresters has a natural areas committee dedicated to the preservation of at least one example of each forest type in the United States. The Ecologists Union is an organization recently formed to promote the preservation and study of natural areas. The Wilderness Society has adopted a policy of support in the preservation of small "wildland patches." There is news also of similar programs in many other countries.

(3) The legal and administrative problems involved in establishing the proposed

system in Illinois have been studied. The division of responsibility for conservation matters in the State government is the main problem which must be faced. At least the following agencies have fields of interest which border on this plan: the Division of Parks and Memorials, the Department of Conservation, the Natural History Survey, the State Museum, and the University of Illinois. Of these the Division of Parks and Memorials and the Department of Conservation are the primary land-holding agencies. The Division of Parks and Memorials already has the legal authority to acquire areas of this sort. However, it would be preferable to have enabling legislation specifically restricting the use and development of tracts acquired as nature sanctuaries.

Now let us return to the resolution passed last year by the Academy. In it are several questions which have been partially but not completely answered.

Question 1. Finding some administrative State agency interested in acquisition of such widely separated areas, has been defined but not finally settled.

Question 2. Proposing some way of administering and protecting them is tentatively answered in the outline referred to above.

Question 3. Devising some method of selecting deserving sites, formulating specifications which sites should meet, and assuring that the purpose for which the sites are set aside be actually preserved. The first two points (method of selecting sites, and specifications) have been answered, but actual selection of areas awaits the availability of sufficient funds to finance a survey. The suggested restrictive enabling legislation would solve the problem of assuring proper use of the tracts.

Further action

Further educational and publicity activities are necessary. Contacts thus far have been restricted to persons thought to be interested in such a program. The larger State organizations such as the women's and sportsmen's clubs as well as the general public should be made aware of the problem. State officials and legislators need to be further acquainted with the plan.

The Academy can broaden its activities on this project if it so desires. A possible program, but one which would require a large amount of work, might be to sponsor a campaign for funds either to make an inventory of natural areas in the State or to acquire areas to be turned over to the State. Such action would tend to produce more respect for the program and make it easier to acquire support of the State government.

There seems to be no doubt that this problem of preserving natural areas is of great immediate importance. Richard Pough of the American Museum of Natural History writes, "There is no question but what it is the number one conservation job today, outside the field of conservation of exploitable economic resources."

In conclusion, the urgency of this matter cannot be stressed too strongly. The remaining natural areas in the State are disappearing very rapidly. Pressure for increased production of food and wood products and residential construction, as well as modern technological developments have destroyed one after another of these strongholds of nature in recent years. It is much easier to obtain information about areas which existed until recently than it is to find areas which still remain.

May 5, 1949

PROPOSAL FOR A SYSTEM OF STATE NATURAL AREA PRESERVES

I. *Definition:*

Natural Area Preserves shall be tracts of land having distinctive natural features worthy of preservation for scientific, educational, and esthetic reasons. These include areas having unusual plant or animal life or geological features and areas having remnants of the original vegetation which has not been disturbed by the activities of man.

II. *Purpose:*

A. *Scientific:* Research in the various fields of land management (agriculture, forestry, wildlife) involves the use of undisturbed areas for comparative purposes, as scientific control or check areas. Scientists in many fields of biology, such as ecology and taxonomy, also make use of such areas.

B. *Educational:* These areas are valuable in teaching a proper understanding of the land upon which we live and are dependent. They would be useful for field trips by school children and others.

C. *Esthetic:* These areas would preserve the last remnants in the State of many na-

REPORT OF THE TREASURER

For the Year May 1, 1948 to April 30, 1949

Balance on hand April 30, 1948	$ 2,011.58	
Less oustanding checks April 30, 1948	423.57	
True Cash Balance		$ 1,588.01

Receipts

Dues:		
Annual members	$ 1,289.00	
Life member	50.00	
Affiliated societies and clubs	27.00	
		1,366.00
Cash for Certificate on Forbes Building		311.31
Interest on Meyer Block Leasehold		4.50
Interest on Series G Bonds		17.50
Sales of Reprints		233.70
Sales of Transactions		72.50
Libraries		6.00
Research Grant from AAAS		260.50
Junior Academy-Sustaining Memberships		240.00
Total Receipts		$ 4,100.02

Expenditures

Council Expenses	$ 49.32
Section Chairmen's Expenses	15.31
Treasurer's Office Expenses	121.51
Secretary's Office Expenses	134.51
Editor's Office Expenses	17.69
Librarian's Expenses	154.93
Printing	221.15
Conservation Council	3.00
Secretary, Honorarium	150.00
Editor, Honorarium	150.00
Research grants	260.50
Purchase of back volumes of transactions	36.00
Purchase of 13—Series G Bonds	1,300.00
Junior Academy	439.38
Total Expenditures	$ 3,053.30
Less outstanding checks	4.81
	$ 3,048.49
Balance in Commercial National Bank of Peoria	1,051.53
	$ 4,100.02

Statement of Resources, April 30, 1949

Balance in Commercial National Bank of Peoria	$ 1,051.53
Certificate of Interest for Meyer Block Leasehold	Value Unknown
United States Savings Bonds, Series G	1,500.00
Total Resources	$ 2,551.53

(Signed) W. W. Grimm, *Treasurer*

tive plants and animals, including such flowers as orchids and gentians. They would serve as "living museums" of untouched or unusual remnants of the natural Illinois landscape for future generations to study and enjoy.

III. *Plan:*

A. *System of administration:* A State operated system shall be established to locate, acquire, and maintain natural areas as Natural Area Preserves.

B. *Size of areas:* These preserves shall be of any suitable size. In most cases they shall include only a few acres.

C. *Restriction of use:* These preserves shall not be developed for recreational use of for the production of a crop such as timber or game.

IV. *Administration:*

A. *Acquisition:* Preserves shall be acquired by donation or purchase.

B. *Management:* Preserves shall be maintained in as primitive a condition as possible. Ordinarily management would include fencing, fire protection (in some situations), and posting with appropriate explanatory signs. The project should be explained to adjacent landowners and to organizations and clubs in the vicinity; and scientific records should be compiled for the areas. Because of the absence of improvements and the small size of the tracts, no resident custodians shall be necessary.

C. *Relation to other public lands:*

1. *Distinction from other public lands:* These preserves shall be limited to areas which are of greatest value if left undisturbed except for study and observation. They shall be distinctive from State parks which are of value for recreational purposes and from State forests and wildlife areas which are of value for timber and game production, respectively.

2. *Preserves within other public lands:* Portions of other public lands may, by cooperative agreement with the administrative agency thereof, be designated as Natural Area Preserves, when these portions would be of greatest value if so designated and restricted.

D. *Advisory board:* There shall be an advisory board consisting of three professional biologists appointed by the Governor.

V. *Basis of proposal:* Organizations actively endorsing this plan include the Illinois State Academy of Science, the Conservation Council, the Ecologists Union, the Friends of our Native Landscape, and the Illinois chapter of the Wildflower Preservation Society.

REPORT OF THE COMMITTEE ON AUDITING

To The Illinois State Academy of Science:

Your committee on auditing respectfully submits the following report:

We have examined the records of the Treasurer, W. W. Grimm, for the year May 1, 1948 to April 30, 1949, and find them correct. The present financial status of the Academy is as follows:

Cash on deposit with the Commercial National Bank of Peoria	$ 1,051.53
Series G, U.S. Savings Bonds, fifteen	1,500.00
Meyer Block Leasehold Certificate No. 15 (value unknown)	0.00
ASSETS	$ 2,551.53
Less Outstanding Checks	4.81
Real Assets	$ 2,546.72

We saw the evidence of purchase of $1300 Series G Bonds in the name of the Academy, but did not verify the Treasurer's possession of the securities listed above.

(Signed) ALLAN K. SMITH *Chairman*,
A. G. ADAMSON
F. W. LUTTEY

REPORT OF THE COMMITTEE ON RESOLUTIONS

I. A Resolution Regarding the Preservation of Small Natural Areas and the Establishment of Nature Preserves

Whereas: (1) the State of Illinois is known to contain small natural areas distinct and precious by reason of their unique ecological features and rare species of plants and animals, and

Whereas: (2) these areas are of little value for public recreation, and

Whereas: (3) these areas are threatened with impairment or destruction by the in-

roads of industry, agriculture or other developments, therefore

Be is resolved: that the Illinois State Academy of Science favors establishment by the State of Illinois of a system of Nature Preserves, for educational and scientific purposes, such as will result in preservation of these areas as sanctuaries and a heritage for future generations.

II. A Resolution Regarding Deceased Members

Whereas: Death has removed from our group the following valued members of the Academy:

John Haynes Bailey
James W. Bristow
Charles K. Carpenter
Margaret E. Engstrom
Albert K. Epstein
E. H. Ehrman
Charles T. Knipp
Frank R. Lillie
C. E. Parmenter
Frederick B. Plummer
Douglas F. Stevens
Eleanor C. Smith
Isabel S. Smith
J. E. Trieschmann
Edgar J. Witzemann
James G. Wray

Be it resolved: (1) That the Academy expresses its grief over their passing, and

(2) That it extends its sincere sympathy to their families, to whom the Secretary is directed to write letters indicating our sense of loss while we extend our sincere sympathy.

III. A Resolution in Appreciation of the Annual Meeting Arrangements

Whereas: Under the present difficulties of crowded facilities, the City of Galesburg, the College, and the State University Division, the High School, the Hotels, and numerous individuals have contributed to a very successful annual meeting of the Academy.

Be it resolved: (1) The Academy extends its sincere appreciation of all of the efforts put forth in its behalf to

The City of Galesburg, The Galesburg Board of Education and Superintendent Lindsey, the Galesburg Press;

Knox College, its Acting President, Mr. McClelland, and its Dean, Mr. Willhite;

The University of Illinois—Galesburg Division, its Executive Dean, Mr. Louttit, and members of his staff;

The Managements of the Hotel Custer and the Broadview Hotel;

The Senior High School, its Principal, Mr. Wooley, and many members of his corps of teachers; and

The Committee on Local Arrangements, composed of Mr. Reed, Chairman, Mr. Aitchison, Mr. Bowen, Mr. Bumstead, Mr. Conklin, Mr. Fiala, Mr. Furrow, Mr. Gilbraith, Miss Hatch, Mr. Neifert, Mr. Elroy Smith, and Mr. Walton.

(2) That the Secretary be instructed to convey this appreciation in writing to each of the above named institutions and Committees..

(Signed) A. C. WALTON, *Chairman*
GEORGE B. FELL
L. R. TEHON

OAS.